SOCIAL DYNAMICS AND SPACE UTILITY OF DOMESTIC CATS (*FELIS SILVESTRIS CATUS*) IN ANIMAL SHELTERS

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(B. SCI (HONS.)) NUS

A THESIS SUBMITTED

FOR THE DEGREE OF MASTER OF SCIENCE

DEPARTMENT OF BIOLOGICAL SCIENCES

NATIONAL UNIVERSITY OF SINGAPORE

2011

ACKNOWLEDGEMENTS

I would like to thank my supervisor, Dr Li Daiqin, for his valuable advice and help throughout the course of my research. He has generously supported my interest in domestic cats despite being a passionate researcher of all things spider-related. I also thank all my friends and colleagues at NUS for their help and support. Special thanks go to Shi Chang, for his tremendous help in obtaining research articles that would otherwise be inaccessible to me and Diego, for the inspiring and often hilarious discussions. I am also very grateful for all the statistical advice patiently given by Professor Yap Von Bing.

I thank the National University of Singapore for funding my research.

I thank the managers of the two animal shelters who made it possible for me to conduct field studies at their premises, Cohen (Mutts & Mittens Pte Ltd), Mohan and Cathy (Pets Villa). I am especially thankful for all the help given to me by the workers there (especially Roda and Danis) and for their forbearance whenever I get in the way of their work.

I am very grateful to my parents for their support, providence and inspiring advice during my research. Last but not the least, I thank Yuan Ting for everything. Her enlivening company and incessant encouragement were the main driving force for the completion of my thesis.

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SUMMARY

Animal shelters traditionally have a constant flux of new cat additions and cats leaving the shelter via adoptions. As a result, shelter cats are unable to form stable hierarchies or relationships, and are often subjected to stressful social situations on top of the confining housing conditions. There are, however, emerging shelters which house cats in relatively more stable groups. This thesis gives an account of the social and behavioural characteristics of group-housed domestic cats that have lived together under such conditions for a long time. I hope to gain a more in-depth understanding of the lives of these animals in order to address the issue of welfare of shelter cats.

Chapter one is an introduction of the thesis exploring general characteristics of the domestic cat and common welfare issues regarding captive animals. Chapter two investigates if a clear hierarchy exists within groups of cats at two local animal shelters. I also determine if the weight and sex of the cat affects its dominance status. In feral cats, it has been established that adult males tend to organize themselves into a hierarchy, with the heavier, older individuals being dominant over lighter, younger males. Reports of hierarchy establishment in confined cats are mixed in their verdict as to what form and degree the cats exert dominance over others. In the same chapter, I also explore the affiliation and agonistic patterns among the cats and report that weight and sex of the cat has no effect on this aspect of their social behavior.

In chapter three, I give an account of the activity budget of cats in two local animal shelters and discussed the effect of housing density and enclosure complexity on their daily behaviors. It has been found that, generally, cats housed under high housing density and low complexity conditions spent less time sleeping, more time in alert rest and groomed themselves more.

Chapter four explores what types of spots within the enclosures are most preferred by the cats and whether dominant cats differ from submissive cats in their usage of the enclosure space. I also describe four space sharing mechanisms evident in the study and investigated if housing density, enclosure complexity, sex, weight and dominance of the cats affected the type of sharing they employed. It has been found that same-sex pairs are less likely to rest close to each other than different-sex pairs.

In chapter five, I examine the quality of rest in the cats, “measured” in terms of the amount of time they spent engaged in short, medium or long bouts of rest, and also in the number of times they moved about in the enclosure. These parameters allow us to infer the degree of restlessness and ability of the cats to relax and have restorative sleep. It has been found that low housing density and high enclosure complexity encouraged more quality rest in the cats. Chapter six concludes the thesis with a general discussion of recurring trends observed during the study.

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CHAPTER 1

GENERAL INTRODUCTION

The domestic cat

The domestic cat is a small feline mammal belonging to the order Carnivora (Carnivora, Felidae, Felinae, *Felis silvestris catus*). It and its wild ancestor, *Felis libyca*, are excellent predators and thrive in a variety of habitats such as forested islands (Harper, 2007), rural farms (Molsher *et al*., 2005) and urban cities (Laundré, 1977). Adult males are considerably larger than adult females and take about three rather than two years to reach their full weight (Liberg, 1981). Cats, both males and females, occupy territories consisting of a home area of about 100 meters in diameter and a larger home range, depending on population density and habitat structure. Females' home ranges vary from 0.0003 to 1.70 square kilometers (Dards, 1979; Jones and Coman, 1982) and adult males' from 0.008 to 3.8 square kilometers (Dards, 1978; Liberg, 1984). Home ranges may overlap considerably, especially with males, who tend to occupy larger home ranges than females (Natoli, 1985c; Molsher *et al*., 2005). Although territories overlap, there is not always mutual tolerance. Animals avoid encounters by sticking to more or less strict individual timetables when travelling through or staying in border areas. Control is by sight over some distance and by scenting conspicuous landmarks along the trail (Natoli, 1985a). Neighbours may tolerate each other at close quarters. Communal rearing has been reported in various studies (Ewer, 1959; Leyhausen, 1979; Lawrence, 1981). Liberg (1981) found evidence for synchrony of oestrus within groups of cats and suggested that this would facilitate cooperation in the rearing and defense of the young. Litter sizes vary from two to eight kittens, with an average of 4.4 kittens per litter (Deag *et al*., 1987).

There have been a great number of studies on social behavior and organization of feral and semi-feral domestic cats. In several studies, cats are generally sighted alone (71-90%) or, less frequently, in groups of two or more cats with sub-adults (van Aarde, 1978; Jones and Coman, 1982). In no case was the social structure of one group exactly the same as another. Females are strictly territorial in one case and mutually tolerant, even cooperative in another. They may or may not tolerate dominant males within their territories (Jones and Coman, 1982). They may be fairly widely spaced or live in a crowd (Crowell-Davis, 2007), share homes and dens or defend them, nurse and raise their young individually or in a kind of partnership (Ohkawa and Hidaka, 1987). Males may share territories and females (Yamane, 1998), or one superior male may terrorize all others and strive to exclude them, if not always successfully, from mating with any female within his "jurisdiction" (Say *et al*., 2002). Young may be tolerated by male and female adults alike (Bonanni *et al*., 2007), or they are cuffed and chased away by all except their mothers. When weaned, they may stay within the group, or they may be chased away (Devillard *et al*., 2003, 2004). It is not entirely clear if all this variability is produced by domestication, genetic differences or environmental differences and pressures. However, the domestic cat's social system is expected to encompass great variation, since they live in habitats as diverse as sub-antarctic islands (van Aarde, 1978) and industrial cities (Rees, 1981), and at densities varying from less than one to more than 2000 per square kilometer (Izawa *et al*., 1982; Langeveld and Niewold, 1985). A review of studies of population densities and spatial organization of domestic cats concludes that, in general, cat populations can be divided into those in which females form groups and those in which they do not.

Animal welfare

Animal welfare has been a major concern for confined animals in zoos, laboratories, farms, animal shelters and homes and has been a subject of research for the past few decades. It is a very broad discipline that comes down to three main concerns: maintaining basic health and functioning of animals, especially freedom from disease and injury, enabling animals to live reasonably natural lives by carrying out natural behaviour and having natural elements in their environment and taking into consideration that animals have "affective states" like pain, distress and pleasure that are experienced as positive or negative in all manner of interactions with them (Fraser, 2008). United Kingdom's Farm Animal Welfare Council has developed the concept of the Five Freedoms in 1979 which now serves as guidelines not only for farming institutes, but also for laboratories and animal shelters. These guidelines stipulate that welfare of domestic animals should include (1) provision of a balanced diet and water, (2) provision of a suitable environment including shelter and a comfortable resting area, (3) provision of proper health care and medical attention, (4) opportunities to express normal behaviors and (5) protection from situations which cause fear and distress.

The growing concern of animal ethics and welfare has sparked numerous research efforts. Specifically, research in animal welfare has focused on improving housing conditions (Rochlitz, 1999; Barnett *et al*., 2001; Bessei, 2006; Ross *et al*., 2009), understanding the effect of environmental enrichment on welfare (Holmes, 1993; Mellen and Sevenich MacPhee, 2001; Abou-Ismail *et al*., 2010), optimizing husbandry procedures to minimize stress (Barnett *et al*., 2001; Gourkow and Fraser, 2006; Abou-Ismail *et al*., 2008) and measures for encouraging natural activity and minimizing stereotypic behaviors in captivity (Shepherdson *et al*., 1993b; Swaisgood and Shepherdson, 2005). Perhaps the most extensively studied aspect of animal welfare is the measuring, monitoring and managing of stress levels in captive animals (Broom and Johnson, 1993; Kessler and Turner, 1999a; Kry and Casey, 2007; Morgan and Tromborg, 2007; von Borell *et al*., 2007).

Sources of stress in captivity

Limited space

One of the major concerns with the welfare of confined animals is the provision of sufficient enclosure space for the animals to carry out normal behaviors (Hediger, 1964). It is, however, a common practice for organizations such as zoos, animal shelters and laboratories to maximize their holding capacity and compromise the amount of space allocated for the animals. Many studies have highlighted the negative impacts small enclosures have on the animals. For instance, housing in smaller enclosures increases rates of agonistic behavior in pigs (Lammers and Schouten, 1985; Wiegand *et al*., 1994), buffalo calves (Napolitano *et al*., 2004), male turkeys (Buchwalder and Huber-Eicher, 2004) and captive dama gazelle (Cassinello and Pieters, 2000). Activity levels in zoo-housed orangutans are also correlated with enclosure volume and usable surface area (Perkins, 1992). Similarly, moving an adult chimpanzee from a small cage to a larger, more naturalistic exhibit can reduce abnormal behavior and increased general activity (Morgan *et al*., 2002). However, several studies have presented evidence that enclosure size has little or no effect on behavior of some captive primates (Wilson, 1982). Housing singly-caged rhesus monkeys in cages six times larger than their standard cage did not reduce abnormal behavior (Kaufman *et al*., 2004). Captive cynomolgus monkeys also may not show reduced abnormal behavior when housed in a larger enclosure (Crockett *et al*., 1995). Clearly, cage size alone does not account for stress in captivity.

Lack of hiding spaces

The restrictive environment of the captive condition is made worse when insufficient structures are provided for animals to conceal themselves from each other and from humans. Animals housed in barren cages often display symptoms of stress. For instance, being housed in barren cages, bank voles (Cooper *et al*., 1996) and gerbils (Wiedenmayer, 1997; Waiblinger and Ko¨nig, 2004) show more stereotypies than those provided with materials that serve as burrows. When mice are given cardboard tubes for hiding, they show a reduction in stereotypic wire-gnawing behaviors (Wurbel *et al*., 1998). Rats may also increase exploratory behaviors and showed less fearfulness when provided with in-cage shelters (Townsend, 1997). Relative to rabbits that are provided with a shelter and nesting materials, those housed in barren cages exhibit more restlessness, bar-gnawing stereotypies, timidity and self-grooming (Hansen and Berthelsen, 2000). When a camouflage barrier is provided, captive gorillas exhibited less aggressive and stereotypic behaviors (Blaney, 2004). These studies point to the single conclusion that a lack of hiding structures in barren enclosures is a major source of stress for captive animals.

Presence of humans

Animal shelters are often established with the objective of re-homing abandoned or rescued animals. Hence, they are "open" for potential adopters to view or even handle the animals. The unpredictable presence of humans may be a significant stressor for animals held in captivity. The effect of visitors on zoo-housed animals has been widely studied and a general consensus that visitors are a potential source of stress for captive animals has been established (Wells, 2005). Visitor presence and level of activity has been shown to increase aggression in golden-bellied mangabeys (Mitchell *et al*., 1991) and laboratory chimpanzees (Lambeth *et al*., 1997). The presence of visitors also decreases play and other positive social behavior in cotton-top tamarins (Glatston *et al*., 1984), and in captive chimpanzees, the presence of large visitor groups is associated with decreased foraging, grooming and play (Wood, 1998). The overall activity in captive leopards is also suppressed in the presence of visitors and large visitor crowds are shown to increase stereotypic pacing (Mallapur and Chellam, 2002). Visitor presence also reduces general activity in captive grey-cheeked mangabeys (Hall, 2005) and Soemmerring's gazelle (Mansour *et al*., 2000).

Routine husbandry

Animals living in captivity are inevitably subject to at least occasional handling by humans, and in many cases, this has been shown to induce stress (Balcombe, 2004). Even repeated events such as cage cleaning continue to evoke physiological and behavioral stress response in captive rhesus monkeys (Malinow *et al*., 1974; Line *et al*., 1989) and rats (Saibaba *et al*., 1996; Duke *et al*., 2001; Sharp *et al*., 2003). Inconsistent handling practices have also been shown to cause higher stress levels in cats housed at a rescue center (Gourkow and Fraser, 2006). Husbandry procedures carried out during an animal's normal sleeping period is also shown to affect subsequent sleep behaviour and welfare of rats. In a study of laboratory rats, it is found that allowing husbandry procedures to be carried out during the day (when the rats are expected to be inactive/asleep) causes the animals to display indicators of reduced welfare (e.g. less sleep, elevated chromodacryorrhoea, lighter thymus glands, higher aggression) relative to rats for which husbandry procedures are carried out at night (a period of activity and wakefulness) (Abou-Ismail *et al*., 2008).

Abnormal social groups

Occasionally, husbandry procedures require animals to be housed in social groupings that will not generally occur in nature, and such “unnatural” housing conditions may induce significant stress. For instance, feral dogs characteristically live in packs (Daniels and Bekoff, 1989), but when housed singly, laboratory dogs display more abnormal behaviors than do group-housed dogs (Hetts *et al*., 1992; Hubrecht *et al*., 1992). Morgan and Tromborg (2007) also described an unusual social setting for a group of Japanese macaques. This species live in multi-male, multi-female groups in the wild. Yet an exhibit in an unnamed zoo consists entirely of juvenile males. These animals were reported to show social tension and very little natural activity, engaging instead in intensive monitoring of the others in their group. In the feral condition, domestic cats only congregate where food availability is high and have often been observed to disperse immediately after being fed by humans (Laundré, 1977; Natoli, 1985c; Mirmovitch, 1995; Natoli *et al*., 2001). Under such conditions, they are able to retreat from agonistic encounters and avoid potential conflicts. It is not known how housing unrelated domestic cats in groups in animal shelters will affect their welfare when such conflict avoidance strategies become ineffective.

Welfare of domestic cats

Of particular interest is the welfare of domestic cats housed in laboratories, animal shelters or homes. As natural predators, there is a general perception that domestic cats need to "roam freely" in order to engage in "natural" behaviors like hunting and marking territories, a space not afforded in confined situations. Yet, cats continued to be kept in captivity as test subjects in laboratories or as pets in homes. This has sparked an interest in the welfare of confined cats. To date, research has focused on understanding "normal" behavior and activity level of cats (Curtis *et al*., 2003; Molsher *et al*., 2005; Overall *et al*., 2005), space use in indoor conditions (Bernstein and Strack, 1996), importance of environmental enrichment (Ellis, 2009) and behavioral enrichment (Shepherdson *et al*., 1993b; Ellis and Wells, 2010), and the adaptation of cats to group-housing conditions in shelters (Kessler and Turner, 1999b; Ottway and Hawkins, 2003).

Many studies have also been concerned with the sources of stress in confined cats. Stress in cats was typically measured either physiologically, in terms of basal urinary cortisol levels (Lichtsteiner and Turner, 2008) or urine cortisol-to-creatinine concentration ratio (McCobb *et al*., 2005), or behaviorally using the cat stress score developed by Kessler and Turner (1997) and used in many studies (Ottway and Hawkins, 2003; McCobb *et al*., 2005; Kry and Casey, 2007). However, it should be noted that no correlation between the cat stress score and urine cortisol-to-creatinine ratio was found (McCobb *et al*., 2005).

Several studies investigated the effects of housing conditions on stress levels in cats. One study of indoor-only domestic cats in private households has revealed positive correlations between human density, number of persons per household and amount of space available to cats on basal urinary cortisol levels whereas housing style (single or multi cat) and the individual's dominance status did not influence cortisol levels (Lichtsteiner and Turner, 2008). Basal urinary cortisol levels are also known not to be significantly different between cats housed in private households and shelters. In a separate study, urine cortisol-to-creatinine ratios were found to be significantly lower in cats in the more environmentally enriched shelters relative to cats in the traditional shelters and was highest among cats with high exposure to dogs (McCobb *et al.*, 2005). Gourkow and Fraser (2006) also compared stress levels between cats housed in four different housing conditions: (1) basic single treatment, where cats were handled in an inconsistent manner by various staff and housed singly in relatively barren cages, (2) enriched single, where singly-housed cats were provided with perching and hiding structures, (3) basic communal, where cats were housed in groups and (4) enriched communal, where cats were housed in groups in enriched enclosures. The study reported higher stress levels in cats under basic single treatment compared to the other three treatments, but no significant differences among the three treatments. Another study compared stress levels in two separate animal shelters which housed cats in different settings (Ottway and Hawkins, 2003). One of the shelters housed 33-65 cats communally in enclosures ranging from 140 to 280 square meters in floor area, while the other shelter housed cats singly or in pairs (for cats previously socialized with each other) in discrete cages measuring 2.5 by 1.6 by 2 meters. Although the study found great difference in mean cat stress score in cats housed communally relative to those in discrete-unit housing, there are too many confounding factors (e.g. housing density) in the study for concluding on which housing arrangement is preferable. Furthermore, none of these studies has directly addressed the effect of housing density on welfare of shelter cats. Kessler and Turner (1999a) is the first and only study to focus on the issue of housing density but they merely reported a strong correlation between group density and stress level, and that cats appeared “weakly tensed” when a housing density of 0.6 animals per square meter was reached. One of the objectives of this thesis, therefore, is to investigate the effects of housing density on several aspects of living in animal shelters such as affiliation level among cats and how they share the limited enclosure space.

Other studies have investigated activity budgets of cats confined in laboratory or animal shelter conditions for various purposes. Podberscek and company (1991) monitored the behavior of a colony of eight laboratory cats and found that cats made more direct contacts with an unfamiliar person than a familiar person who entered the room. They also observed that the cats preferred to rest above the ground and were more likely to rest alone than with other cats. Grooming behavior has also been studied in 11 indoor group-housed cats to confirm that grooming is primarily organized and controlled by a central or internal generator rather than by peripheral or cutaneous stimulation (Eckstein and Hart, 2000b). In a separate study, the behavioral responses to the presentation of enrichment objects was monitored in 10 singly-housed cats, and was found that introduction of objects in the cages decreased inactivity and self-play but increased exploratory and object-play behaviors (deMonte and LePape, 1997). Monk (2008) also studied how length of stay at a shelter, housing density, sex of cat and number of roommates affected the activity budget and social behavior of cats. As these studies monitor activity budgets for different reasons, they categorize behaviors in varying clusters to suit their purposes. My work presents a more detailed profile of interactions and activity patterns of group-housed shelter cats and attempt to compare and explain activity budget differences obtained from various studies. As resting behavior is also linked with stress and welfare of captive animals (Melfi and Feistner, 2002; Abou-Ismail *et al*., 2007), my study also examined the quality of rest these shelter cats have.

Review of housing requirements of domestic cats

The result of many welfare studies for confined cats has produced several publications recommending ideal housing measures (Rochlitz, 1999; Overall *et al*., 2005; Rochlitz, 2005, 2007; Ellis, 2009). Generally, it is recommended that the enclosure should be large enough to allow cats to express a range of normal behaviors and to keep a critical distance (1-3 meters) away from others if housed in groups (Barry and Crowell-Davis, 1999). Kessler and Turner (1999a) suggest that there should be at least 1.6 square meters of floor space per cat for group-housed cats while Rochlitz (2007) recommends that a single cat can be housed in a cage with a minimum floor area of 1.5 square meters, with another 0.75 square meters for every additional cat. The cage should be high enough for a human to enter and be at least 1.5 meters in height so that the cat can fully stretch and jump freely. Shelves and elevated resting spaces should be provided as cats prefer to use elevated areas as vantage points to monitor the surrounding (AWR, 1985; Rochlitz, 2005; Ellis, 2009). Hiding structures such as carriers and BC SPCA Hide & Perch™ boxes should be provided as cats housed in communal rooms are more likely to hide when stressed (Overall *et al*., 2005; Kry and Casey, 2007). Schroll (2002) suggests that each cat should be given two types of resting places, one on the floor enclosed on three sides and another elevated with a good view. Visual stimulation in the form of two-dimensional video-tape sequences, notably that combining elements of prey items and linear movement, may also hold some enrichment potential for domestic cats housed in rescue shelters (Ellis and Wells, 2008). These housing recommendations were based on inferences derived from behavioral observations of the cats rather than experimental testing. For instance, it was recommended that hiding structures be provided because stressed cats have been observed to hide more (Kry and Casey, 2007). However, no direct study as to whether hiding actually relieves stress, or how the absence of hiding structures will affect welfare was conducted. Similarly, providing sufficient elevated resting places was considered to be imperative because these are preferred spots and cats tend to rest alone than to share a space with others (Podberscek *et al*., 1991). Yet, how the behavior, social interactions and welfare of cats will differ under circumstances when insufficient elevated resting places were provided remains unknown. My study investigated the effect of enclosure complexity (presence or absence of resting structures) on affiliation and agonism among group-housed cats and their activity budget and behavioral patterns. I also looked at how they would share the enclosure space and how these factors would influence the quality of their rest.

Cats and animal shelters in Singapore

The number of feral cats roaming freely on the Singapore main island is estimated to be around 60,000 individuals (personal communication, Cat Welfare Society, 2010), the largest groups are located at Eunos and Changi due to rampant abandonment of cats there. Around 6000 community cats are sterilized every year and in most HDB estates, around 70% of owned cats are sterilized (Cat Welfare Society, 2010). Large congregations of feral cats have been generally considered a nuisance by Singaporeans due to several reasons. In intact cat colonies, loud caterwauling sounds are emitted by females during mating seasons and are a source of great nuisance to residents in the area. Irresponsible cat feeders also dirty the common grounds when they fail to clean up after offering food to the cats. As a result, organizations such as Society for the Prevention of Cruelty to Animals (SPCA) and Agri-Food & Veterinary Association of Singapore (AVA) have been contacted frequently to send workers to resident areas and conduct culling or capture-neuter-return procedures. As a result, in the past five years or so, several cat lovers have established private animal shelters to provide refuge for rescued strays or abandoned pet cats. A superficial search identified eight major animal shelters in Singapore: SPCA (Mount Vernon Road), Pets villa (Pasir Ris), Mutts n mittens Pte Ltd (Pasir Ris), Metta Cattery (Pasir ris), Mdm Wong Shelter (Pasir ris), Kittycare haven (Lim Chu Kang), Noah’s Ark Natural Animal Sanctuary (moved to Malaysia) and Action for Singapore Dogs (Lim Chu Kang). All of these shelters run on volunteer services and public donations.

Of the eight animal shelters, Pets Villa and Mutts & Mittens Pte Ltd were of particular interest to me because of the unique way they are managed. Besides taking in stray cats and putting them up for adoptions, these animal shelters also "rent" out rooms for cat owners who have several cats and nowhere to house them. As a result, cat groups in these "rented rooms" remain relatively stable, with infrequent additions and no removal of cats by adoption. This is an interesting opportunity to study the social dynamics of unrelated cats that are forced into close proximity with each other for long periods of time in stable groups. As more and more cat lovers become aware of such animal shelters, more of such facilities might be established to meet the demands for boarding rooms. Such a study would shed valuable insight into the livelihoods of cats housed under these unique circumstances and provide valuable tips to ensure good welfare for the cats.

Specifically, this thesis aims to answer the following research questions:

1) Do cats housed in animal shelters establish clear hierarchies or dominant-submissive relationships with group members? Do weight and sex of cats influence their dominant status?

2) Are cats generally affiliative or agonistic with each other? Do factors such as housing density, weight and sex of cats predict the level of affiliation and agonism in cats?

3) What is the activity budget for shelter cats? Are the activity budgets different between cats housed in the two animal shelters? How do housing density and enclosure complexity affect their activity and behavior?

4) What type of “spots” in the enclosures do the cats use most often? Does their dominance influence their spot preference?

5) How do cats share the limited enclosure space? Do factors such as housing density, enclosure complexity, weight, sex and dominance of the cat influence the type of space sharing mechanism they employ?

6) What is the quality of rest exhibited by shelter cats? How is it affected by housing density and enclosure complexity?

CHAPTER 2

SOCIAL DYNAMICS OF GROUP-HOUSED DOMESTIC CATS (*FELIS SILVESTRIS CATUS*) IN ANIMAL SHELTERS

ABSTRACT

Social structure of feral cats has been well established and understood to be very flexible. Reports on the social structure of confined cats, however, remain divided on the existence of clear hierarchies among group-living, unrelated cats. This study attempted to describe the social structure of domestic cats housed under animal shelter conditions. I observed a total of about 75 cats housed at two local animal shelters and recorded all inter-cat interactions using continuous and focal sampling methods. No clear linear hierarchy can be constructed due to a lack of information on dominant-submissive status between many dyads. Multinomial logistic regression analysis revealed no significant relationship between weight and sex of the cat with its dominance status. Ordinal logistic regression analysis also showed that higher housing density lowers the chance that a pair of cats will be affiliative with each other. Sex and weight difference between a dyad did not significantly affect the level of affiliation in the cats. Agonism was also not correlated with housing density and sex and weight difference in a dyad.

2.1. INTRODUCTION

2.1.1. Hierarchy and dominance

Historically, cats are considered to be an asocial, solitary species that have no need for companionship and prefer to be alone (Milani, 1987). However, it is now widely accepted that cats have a very flexible social structure, being able to survive alone, as well as living in stable colonies of varying sizes centralized around clumped food resources (Laundré, 1977; Natoli, 1985c; Mirmovitch, 1995; Natoli *et al*., 2001). In the feral condition, these colonies tend to be matrilineal in nature, the smallest colonies consisting of a single queen and her dependent young while larger colonies are composed of several related queens engaged in cooperative breeding, nursing and nest guarding (Liberg and Sandell, 1988; Macdonald *et al*., 2000; Crowell-Davis *et al*., 2004). Living in colonies improves fitness through cooperative caring for the young (Bradshaw, 1992). Males tend to disperse from their natal groups within five years of age (Podberscek *et al*., 1991).

Within these colonies, sociobiologists disagree on whether or not a hierarchical system of dominance exists. On the one hand, some studies have shown that males form stable dominance hierarchies based on weight and age (Podberscek *et al,* 1991), where the heavier and older cats are ranked higher than smaller, younger cats. Other studies infer linear hierarchies based on win-lose outcomes of encounters between pairs of cats (van den Bos and Buning, 1994; Knowles *et al*., 2004). On the other hand, some studies suggest that no such hierarchy can be formed (van den Bos, 1998) and that while there may be one or two “dominant” cats in a group, the remaining cats showed no organized hierarchy (Beaver, 1992).

Nevertheless, most studies have recognized that cats establish dominance using ritualized signals. Cats signal deference or submission by avoiding another cat (walk around, diverts its path when another cat approaches, wait for another cat to move from an area before moving in, avoiding eye contact first), or employing body, tail and ear postures such as crouching, curling tail lateral to the thigh, rolling onto the back and flattening ears against the head (Feldman, 1994; Bradshaw and Cameron-Beaumont, 2000; Knowles *et al*., 2004). Dominant cats display their status by blocking the movement of subordinate cats, supplanting (take over their resting spot), mounting, pawing, chasing and staring at them. They will also assume dominant body postures like stiffening the ears and rotating them so that the aperture opens laterally, standing tall with hind limbs stiff and extended and raising the base of the tail while allowing the remainder to droop (Crowell-Davis, 2007).

As no consensus on whether group-housed cats establish clear hierarchies exists, this study aims to investigate whether a linear hierarchy exists among group-housed cats in local animal shelters and to test the hypothesis that weight and sex of the cats will influence its dominance status.

2.1.2. Affiliation and agonism

Within a colony, cats establish affiliative relationships with certain preferred associates. Not only are they found closer to these associates more often than they are to other con-specifics, they also engage each other in various activities such as mutual grooming, play and sharing resources (Crowell-Davis, 2007). Affiliates have also been observed to greet each other when they meet by nose-touching and allo-rubbing (where two individuals rub their heads, bodies and tails against each other). Preferred associates also often choose to rest together even when there is sufficient space for them to spread out. Since this phenomenon is also observed on hot humid days, resting together is considered to be a social activity rather than a thermoregulatory one (Crowell-Davis, 2007).

While some cats are affiliative with each other, others show varying degrees of agonism towards con-specifics. Most often, aggression is displayed against strangers who intrude on a colony's territory (Crowell-Davis *et al*., 2004). The cats involved in an agonistic encounter may stare at each other, stand sideways such that the opponent sees the flank of the body, or approach each other until one cat turns and moves away. Seldom do agonistic encounters unfold into a full fight, but when no submission signals are given by either cat, pawing, hissing, chasing and biting can occur (Crowell-Davis, 2007). These are rare instances since cats in the feral condition seldom come into close proximity to each other to warrant a fight.

In some animal shelters however, unrelated stranger cats are forced into close proximity with each other for prolonged periods of time when cats are housed in groups. These groups are relatively unstable due to addition of cats to the shelter and removal of cats by adoption (Ottway and Hawkins, 2003). This study is the first to investigate the pattern of affiliation and agonism in group-housed cats in animal shelters and to determine if housing density and enclosure complexity influence levels of affiliation and agonism among the confined cats.

2.2. MATERIALS AND METHODS

2.2.1. Study site

2.2.1.1. Mutts & Mittens Pte Ltd

Mutts & Mittens was established in September 2003 at 11 Pasir Ris Farmway 2, Singapore. Each room measured 3.55 by 4.90 by 2.70 meters. A wooden beam was placed across the front at a height of 2.4 meters for the cats to perch. Three sides of the wall were also lined with horizontal planks 1.05 meters off the ground on which the cats can rest. Each room was furnished with three litter boxes (covered), one scratch post, and hiding/resting structures such as baskets, cages, bags and cat carriers. The cats had access to dry food and water throughout the day, and the dishes were replenished daily. All the rooms were cleaned daily.

2.2.1.2. Pets Villa

Pets Villa was established in 2004 at 61 Pasir Ris Farmway 3, Singapore. Approximately 200 cats were housed in 40 rooms and another 30 cats were allowed to roam freely within the compound. Each room measured 5.28 by 1.65 by 1.76 meters, and were furnished with baskets, stools, and shelves as resting spaces for the cats. Each room also had one or two litter boxes, a scratch-post, a water bowl and a food dish. The cats had access to dry food and water throughout the day, and the dishes were replenished daily. Once a day, the cats were fed with Aristo-Cats Yi Hu brand of mackerel and sardine in jelly. All the rooms were cleaned daily.

2.2.2. Subjects

The cats had been sterilised, vaccinated and microchipped. At the start of the study, the cats' weight and sex were recorded. Cats for which the weight and/or sex could not be determined were excluded from all analyses. Age of the cats could not be determined but all cats included were adults (ages 1-9) at the time of study.

In Mutts & Mittens, four rooms were selected for observation because they contained the same type and number of "furniture" within them. These rooms contained eight, 11, 12 and 15 cats respectively. Density of the rooms was calculated as number of cats per square meter.

In Pets Villa, seven rooms were selected for observation because they contained the same type and number of "furniture" within them. Out of these rooms, three were "high density" rooms containing six, seven and eight cats respectively, and four were “low density” rooms containing three to four cats each.

None of these cats were related to each other, but they had all been housed together for at least six months.

2.2.3. Data collection

Observations were conducted on weekdays from 10 am to 4 pm. Weekends were avoided due to higher visitor frequency, which may introduce confounding factors to the observations. Observation sessions were paused if there were interruptions due to cleaning or feeding and restarted 15 minutes after the end of the disturbance.

All observations were conducted by one observer who sat outside the room. No physical interactions between the observer and cats were allowed. The observer sat outside the rooms for two hours on five consecutive days prior to the start of the study to habitualize the cats to her presence. After which, 15 minutes were allowed to lapse before each observation session began. All cats were easily identified by distinguishing features like its coat colour or collar.

For Mutts & Mittens, focal sampling method was used. A cat was randomly selected and observed for 15 minutes, during which all location, activity, duration of activity were recorded. At the end of the 15-minute sample, a scan sample was obtained where locations of all cats in the room were noted on an enclosure sketch. Another cat was then randomly selected for the next 15-minute observation period. The previous focal cats were removed from the selection process until all cats were sampled, where upon the process was repeated to obtain multiple 15-minute samples for each cat. All inter-cat interactions were recorded regardless of which cat was the focal animal.

For Pet Villa, continuous sampling method was used. Each room was observed for five random days for six hours each, giving a total of 30 hours for each room. A stopwatch was set to run from start to the end of the 6-hour period. At time 0:00, the locations of all cats were noted on an enclosure sketch (Appendix B). Thereafter, when a cat moved from its resting spot, the time on the stopwatch was jotted down next to its sketched position. When the cat settles down again at another spot, the location and time was noted on the same sketch. This was done for all cats for all movements so that the detailed movements of the cats can be traced (See Chapters 4, 5). At the same time, a scan sample was obtained every 15 minutes, where location and activity of all cats were noted in a separate sketch. Scan sample data was used to analyze activity budget (Chapter 3) and "favoured spots" (Chapter 4). All inter-cat interactions were also recorded as frequencies. For long bouts of interactions such as allo-grooming, a bout was considered separate from a previous bout if at least 10 seconds had lapsed between them.

In order to investigate effects of enclosure complexity on various parameters, four rooms in Pets Villa were selected for site manipulation. Two high density rooms (7, 32) and two low density rooms (9, 19) were first observed for five days (as described above) under a "high complexity" condition. To create a "low complexity" condition, the shelves, baskets, stools and other removable "furniture" were then removed from the room and the cats were observed in the same manner for another five days. At the end of each day, the furniture was returned to the rooms, as per requested by the animal shelter. The cats were first acclimatized to the removal of furniture for two hours for five consecutive days prior to the actual data collection, and subsequently given 30 min after the removal of the furniture to settle down before each observation period began. A longer observation period was not permitted on grounds that the removal of furniture would elevate stress in the cats.

This study conforms to the regulations and is approved by the Office of Safety, Health & Environment (OSHE) after conducting the Project Risk Assessment (Ref: OSH/RA/F02.01).

2.2.4. Data analysis

2.2.4.1. Hierarchy and dominance

All inter-cat interactions were recorded and categorized into “dominant” or “submissive” behaviours. Table 2.1 describes the interactions recorded. Dominant-submissive relationship was determined for each pair of cats in a room. For each pair of cats (A-B), the dominance score was calculated as the sum of (i) the number of dominant acts A performed on B (+ve), (ii) the number of dominant acts B performed on A (-ve), (iii) the number of submissive acts B performed on A (+ve) and (iv) the number of submissive acts A performed on B (-ve). A positive score indicates that cat A is dominant over cat B while a negative score indicates the reverse. Vries *et al* (1993) described a method for constructing a linear hierarchy if dominance relationship is known for most dyads in a group. However, a hierarchy could not be constructed for all rooms in my study due to the presence of too many unknown dyadic dominance relationships. Instead, a cat is considered a dominant cat in the room if it is dominant over more cats than it is submissive to. Multinomial logistic regression was used to determine if weight and sex of the cat predicts its dominance. Each room was analyzed separately as dominance is a relative measure in this study (i.e. A dominant cat in one room is not necessarily dominant in another room). All statistical analyses hitherto were run using PASW Statistics 18 (SPSS inc. USA).

Data from Pets Villa, rooms 9, 15, 19 and 21 (low density rooms) were excluded from this analysis because dominance relationships among the cats cannot be determined (due to insufficient interactions observed). Rooms 8 and 32 were excluded from the analysis because there was only one male cat in each room, rendering the analysis of effect of sex on dominance erroneous.

2.2.4.2. Affiliation and agonism

All inter-cat interactions were recorded and categorized into "affiliative" or "agonistic" behaviours. Table 2.2 describes the interactions recorded. A pair of cats is considered affiliative/agonistic if they engaged in more than three affiliative/agonistic acts, or they engaged in more affiliative acts than agonistic acts/more agonistic acts than affiliative acts respectively. The affiliative and agonistic behaviours were ranked from one to five separately, in increasing levels of intensity (Table 2.2). For each pair of cats, their sex (same/different), weight difference, density of the room they are in and their affiliation/agonism scores were determined. If a pair of cats exhibited more than one type of affiliative behaviour, only the highest is scored. For instance, if a pair of cats exhibited both allo-rubbing (rank 1) and resting together (rank 4), the affiliation score for this pair is scored 4. Ordinal logistic regression was used to analyze if enclosure density, sex and weight difference in a dyad are significant predictors of affiliation/agonism.

Table 2.1: Description of dominant and submissive interactions recorded

Behavior	Description
<u>Dominant</u>	
Supplant	Displacing another cat from its sitting/resting spot and occupies the vacated spot for at least 10s
Block	Cutting in front of or walks side-by-side with another walking cat, causing the latter to stop or to change its course
Stare	Maintaining continuous eye-contact with another for more than 5s, disregarding other external stimuli
Chase	Takes 3 running strides towards another cat
<u>Submissive</u>	
Avoid	Stopping or changing the course of its path or moves off from a resting spot when another cat is approaching.
Crouch	Limbs are bent and held close to the body, head is lowered and belly touches the floor
Hiss	Sound produced when threatened
Flinch	A sudden, recoiling action in reaction to the presence of another cat
Flee	Takes 3 running strides away from another cat

Table 2.2: Description of affiliative and agonistic interactions observed

Rank	Behavior	Description
	<u>Affiliative</u>	
1	Allo-rub	Rubbing of cheek, trunk or tails against another cat
2	Nose touch	Greeting behavior involving a brief nose-to-nose touch between two cats
3	Eat with	Sharing the same food bowl at the same time without any agonistic behaviors
4	Rest together	Sharing the same resting spot at the same time without any agonistic behaviors
5	Allo-groom	Licking, cleaning, nibbling of another cat without any agonistic behaviors
	<u>Agonistic</u>	
1	Avoid	Stopping or changing the course of its path or moves off from a resting spot when another cat is approaching.
2	Stare	Maintaining continuous eye-contact with another for more than 5s, disregarding other external stimuli
3	Hiss	Sound produced when threatened
4	Paw	Swatting a front paw at another cat, regardless of actual contact
5	Chase	Takes 3 running strides towards another cat

2.3. RESULTS

2.3.1. Hierarchy and dominance

A total of 201 dominant acts and 185 submissive acts were observed in Mutts & Mittens, and 115 dominant acts and 147 submissive acts were observed in Pets Villa (Table 2.3). A linear hierarchy cannot be constructed from the dominant-submissive relationships (see Appendix A) due to presence of too many dyads with unknown dominant relationships. Cats in low density rooms (rooms 9, 15, 19, 21) interacted with each other very rarely; hence their dominant-submissive relationships cannot be determined. Therefore, data from these rooms are excluded from any further analyses on effects of cat dominance. Multinomial logistic regression analysis showed that weight and sex of the cat do not predict its dominance (Table 2.4).

Table 2.3: Number of interactions observed in each room

Cattery	Room	Dominant	Submissive
Mutts & Mittens	A	121	99
	B	30	13
	C	34	43
	D	16	30
Pets Villa	7	50	13
	8	35	76
	9	12	32
	15	2	2
	19	2	0
	21	2	4
	32	12	20

Table 2.4: Results from multinomial logistic regression analyses of effect of weight and sex on dominance

Room	χ^2	***df***	***P.***
7	1.9	2	0.39
A	0.69	2	0.71
B	2.2	2	0.33
C	0.51	2	0.78
D	0.67	2	0.72

2.3.2. Affiliation and agonism

A total of 276 affiliative acts and 228 agonistic acts were observed in Mutts & Mittens, and 234 affiliative acts and 144 agonistic acts were observed in Pets Villa (Table 2.5). Some rooms have more affiliative dyads than agonistic ones (rooms B, 7, 19, 32), two have more agonistic dyads than affiliative ones (8, 9), some have approximately equal number of affiliative and agonistic dyads (A, C, D) and the remaining rooms have very few dyads for which they are clearly affiliative or agonistic (15, 21).

The overall regression model for Pets Villa (low complexity condition) showed significant results (χ^2 = 8.78, *df* = 3, *P* = 0.032) while those for Pets Villa (high complexity condition) (χ^2 = 6.28, *df* = 3, *P* = 0.099) and Mutts & Mittens (χ^2 = 1.67, *df* = 3, *P* = 0.643) did not. For Pets Villa (Low complexity condition), enclosure density was the only predictor found to be significant, while weight difference and sex in a dyad did not affect affiliation levels (Table 2.6). The results state that for every unit increase in density, we would expect a -3.407 increase in the ordered log odds of the cats being in a higher level of affiliation.

The overall logistic regression models described no significant relationship between the three predictors (enclosure density, sex and weight difference in a dyad) and the agonism levels in Pets

Villa (high complexity: $\chi^2 = 2.05$, $df = 3$, $P = 0.563$; low complexity: $\chi^2 = 3.84$, $df = 3$, $P = 0.279$) and Mutts & Mittens ($\chi^2 = 6.74$, $df = 3$, $P = 0.081$).

Table 2.5: Number of affiliative and non-affiliative interactions observed in each room

Cattery	Room	Affiliative	Non-affiliative
Mutts & Mittens	A	108	137
	B	92	24
	C	45	45
	D	31	22
Pets Villa	7	79	11
	8	11	85
	9	1	27
	15	24	2
	19	79	1
	21	0	4
	32	40	14

Table 2.6: Results from logistic regression for testing the effects of weight, density and sex of cat on affiliation level

	Parameter estimates				
Factors	Estimate	S.E	Wald	*df*	*P.*
Weight Difference	0.272	0.382	0.507	1	0.477
Density	-3.407	1.34	6.465	1	**0.011**
Sex	-0.336	0.552	0.37	1	0.543

2.4. DISCUSSION

2.4.1. Hierarchy and dominance

A linear hierarchy cannot be constructed from the dominant-submissive relationships between pairs of cats because too many dyads had unknown dominant relationships. The primary reason for this is the lack of any dominant-submissive interactions between many pairs of cats. With the exception of room 9 (in which a clear linear hierarchy can be inferred), absolutely no interactions were observed for 40-65% of all dyads in the remaining rooms. This suggests an extremely high tendency for shelter cats to avoid interacting with each other. This contrasts with a study done on a group of confined female laboratory cats (van den Bos and Buning, 1994). The study reported an inability of the cats to avoid each other, or maintain a critical distance from one another (even though housing density is comparable to that of the present study), and suggested that this might have led to the development of a rank among the cats at the end of the study. Although it is likely that a longer observation period captured more agonistic interactions in that study (89 hours, cf. 30 hours per room in the present study) and allowed for rank determination, a longer observation period might not yield the same outcome for the present study. Most of the observed interactions were performed by just a few pairs of cats in both animal shelters. In Mutts & Mittens, 65% of all dominant-submissive interactions were exhibited by just 12.4% of all dyads while in Pets Villa, 60% of all interactions were exhibited by just 12.5% of all dyads. A longer observation period would just capture more interactions in a small number of dyads and is not likely to provide additional relationship information for the remaining ones. Even a study which observed a group of indoor cats for about 450 hours could not resolve the dominant-submissive relationships of 41% of all possible dyads in that study (Knowles *et al*., 2004).

My results also show that weight and sex of the cat do not predict its dominance status in all the rooms for which this analysis was performed. Of all the studies on effects of weight, sex and age on dominance of animals, some report significant correlations (Townsend and Bailey, 1981; van den Bos and Buning, 1994; Cloutier and Newberry, 2000; Holand *et al*., 2004) while others find no direct effect (Bernstein and Strack, 1996; Cote, 2000; Vervaecke *et al*., 2010). In particular, clear hierarchies based on weight and sex have been documented in free-living feral cats (Natoli *et al*., 2007) as well as confined cats (Knowles *et al*., 2004). It is important to note that the latter study excluded eight cats (n = 27) when constructing the hierarchy on the basis that they did not have unambiguous relationships with three or more cats other than the top and bottom ranking ones. No such exclusion was performed in the present study as the priority of the present study was to elucidate the dominance patterns in cats rooming together in shelters rather than to construct a linear hierarchy.

This study suggests that group-housed cats in animal shelters do not organize into clear dominance relationships due to a lack of motivation to assert dominance and a stronger preference to avoid agonistic encounters with other cats. Dominance functions to allow priority to preferred resources, but with the supply of excess food and water throughout the day, competition over such resources is minimal. Moreover, the cats were observed to wait on each other during feeding times, that is, allowing another to leave the food bowl before moving in, and have no apparent feeding order (personal observation). Some cats even share the same bowl at the same time with no sign of aggression. Although in most rooms (A - D, 7, 8), one or two cats are clearly dominant over the rest, the remaining cats showed no clear hierarcies, preferring to avoid encounters rather than display dominance/submission. This is particularly obvious in the low density rooms (rooms 15, 19, 21), in which very few dominant-submissive interactions were observed.

2.4.2. Affiliation and agonism

There is no apparent pattern for predicting which rooms will have more affiliative or agonistic dyads. Most studies quantified levels of affiliation and agonism based on the total number of interactions (van den Bos and Buning, 1994; Barry and Crowell-Davis, 1999; Videan and Fritz, 2007; Monk, 2008). This method, however, does not allow for comparisons between studies on affiliation/agonism since studies with longer observation periods tend to capture more interactions. Hence, the present study measured levels of affiliation/agonism by ranking the behaviors according to intensity of affiliation/agonism instead. This method, if applied in other studies, will allow direct comparison of affiliation/agonism in the animals across different studies.

To my knowledge, this is the first study which investigated the effects of housing density on level of affiliation in domestic cats. Housing density was found to influence affiliation levels in Pets Villa: the higher the density, the lower the chances that a pair of cats will exhibit affiliative behaviors. However, this is only seen in the low complexity conditions. Housing density has also been shown to influence affiliation in similar trends in rhesus monkeys (Judge and de Waal, 1993) and chimpanzees (Aureli and DeWaal, 1997), where high housing density was correlated with less allo-grooming in the animals. The present study suggests that high density inhibits social behaviors in domestic cats, but only when the housing situation is compounded by low complexity conditions. This is further supported by the evidence that there is no significant increase in agonism levels, suggesting that the cats are less likely to be affiliative but not more agonistic towards each other as housing density increases. Furthermore, since high density (Kessler and Turner, 1999a) and low enclosure complexity (McCobb *et al*., 2005; Morgan and Tromborg, 2007; Abou-Ismail *et al*., 2010) have been shown to correlate strongly with higher stress levels in captive animals, the fact that high density affected affiliation levels only when enclosure complexity is low suggests that affiliation among cats may be influenced by stress levels. This suggests that stress levels of group-housed cats can be monitored by examining their affiliation patterns, or changes in affiliation levels.

My results also show that density, sex and dyadic weight difference did not influence levels of agonism. Barry and Crowell-Davis (1999) also reported no influence of sex of cats on aggression levels in pairs of indoor cats. It is possible that neutering reduced sexual differences in agonism in both studies since neutering is known to reduce agonistic behavior and territoriality in male cats (Hart and Barrett, 1973).

2.5. CONCLUSION

Dominant-submissive relationships and affiliation patterns are complex in group-living domestic cats. Due to the flexible nature of the social structure in domestic cats, multiple factors like weight, sex and age of the cats, and enclosure density and complexity may influence the outcome of encounters between two cats in a way that is difficult to predict. Nevertheless, this study found a relationship between enclosure density and affiliation levels in domestic cats. High density housing conditions coupled with low enclosure complexity lowers the chances that a pair of cats will exhibit affiliative behaviors. This can be of particular interest for shelter managers as a study of affiliation levels among resident cats might give an indication of the state of welfare the animals have under shelter conditions.

CHAPTER 3

ACTIVITY BUDGET OF GROUP-HOUSED CATS IN TWO ANIMAL SHELTERS

ABSTRACT

The study of activity budget of captive animals is critical as it enables us to monitor changes in behavior in response to the captive condition, and thus allows inferences on the welfare of the animals to be made. Several studies have obtained activity budgets of confined domestic cats housed singly. This chapter aims at providing data on the activity budget of group-housed domestic cats at two local animal shelters and to examine if housing density and enclosure complexity affect activity budget. The activity of the cats was recorded using scan sampling method and Pearson's Chi-square test was used to detect differences in activity budget between high and low density rooms, as well as between high and low complexity conditions. Furniture within selected rooms was removed to stimulate a low complexity condition. Results revealed no difference in activity budgets of cats housed at high densities and those housed at low densities. Enclosure complexity, however, significantly altered their activity budgets. Cats were found to nap less and idle more under low complexity conditions in all observed rooms, and also groomed more under low complexity conditions in low density rooms only. Comparison with activity budgets obtained from other cat studies also revealed that single-housed cats tend to sleep less than those housed communally. These conclusions have important implications on the relationship between housing conditions and welfare of the cats in animal shelters.

3.1. INTRODUCTION

The activity budget of an animal is the allocation of its time to different kinds of activity like sleeping, grooming, feeding and travelling. Activity budget has been extensively studied in many species, including blue tits (Tripet *et al*., 2002), gray whales (Stelle *et al*., 2008) and primates (Huang *et al*., 2003; Hanya, 2004; Jaman and Huffman, 2008). However, very few studies have investigated the activity budget of domestic cats (Podberscek *et al*., 1991; deMonte and LePape, 1997; Rochlitz *et al*., 1998; Eckstein and Hart, 2000b; Kry and Casey, 2007; Monk, 2008), especially those housed communally in animal shelters (Monk, 2008). Method of studying activity budget varies widely among studies. Some studies conduct observations on focal animals (Huang *et al*., 2003; Jaman and Huffman, 2008; Stelle *et al*., 2008) while others collect data via scan sampling methods (Blasetti *et al*., 1988; Prates and Bicca-Marques, 2008) or by obtaining group data (Stelle *et al*., 2008) instead of focusing on individuals.

Activity budget can be affected by internal factors (e.g. age, sex) or environmental factors (e.g. seasonal changes, habitat quality, social context) or a combination of several interacting elements. Age-sex class of animals has been showed to affect activity budget of wild boars (Blasetti *et al*., 1988) and primates (Jaman and Huffman, 2008) In primates, juveniles generally spend more time feeding and playing (Watanuki and Nakayama, 1993; Hanya, 2003), and moving (Maruhashi, 1981) than adults, and females are more active, and spend more time feeding and grooming other group members (Jaman and Huffman, 2008) than males. In the wild, activity budget is also dictated by availability and distribution of food, mate and other resources, and these factors vary with seasonal changes in temperature (Watanuki and Nakayama, 1993; Agetsuma, 1995; Vasey, 2005; Stelle *et al*., 2008). Food availability is also dependent on habitat quality, one of the major factors affecting time spent on foraging and feeding (Li and Rogers, 2004). Activity budget can also be affected by parasite density. Blue tits are observed to sleep more in nests which are highly infested with fleas and females spent more time feeding their young because males provisioned highly infested nests less (Tripet *et al*., 2002).

Activity budgets of captive animals are of particular interest because of their application in animal welfare matters. Comparisons between behaviors of captive and free-ranging animals are a popular way of assessing quality of enclosure and management systems (Höhn *et al*., 2000; Melfi and Feistner, 2002; Ishiwata *et al*., 2008). For instance, Beisner and Isbell (2008) reported that macaques spend more time foraging and less time grooming when given grass as a substrate compared to gravel substrate and suggested that grass is more efficient at stimulating foraging and grooming to levels more comparable to that of wild populations. Leopard cats are also found to increase exploratory behaviors and decrease stereotypic pacing when given multiple feedings with hidden food (Shepherdson *et al*., 1993a).

This chapter aims at providing data on the activity budget of group-housed domestic cats at two local animal shelters and to examine if housing density and enclosure complexity affect activity budget. Unfortunately, it is difficult to compare the activity budget of confined domestic cats to that of feral populations because the data for free-ranging cats remain vague – studies merely report that feral cats are mostly visually observed, and hence active, at sunrise and sunset (Konecny, 1987; Haspel and Calhoon, 1993). However, inference of cat welfare may still be made from activity budget data. It is widely accepted that cats spend most of their time sleeping (Hart 1978) and it is suggested that sleeping may be used as a coping mechanism by cats which are stressed (Monk, 2008). Although some studies have found a negative correlation between stress levels and resting behavior (Crowell-Davis *et al*, 2004; van den Bos, 1998), no study has looked at the effects of housing density on resting and other activities. This study predicts that cats housed in lower density rooms would spend more time sleeping than those in higher density rooms. This study is also the first to compare activity budgets obtained from cats housed at two different animal shelters and to discuss how different husbandry practices might have resulted in significant differences in the activity budget. Besides comparing between the two local animal shelters, this study also did a comparable study of activity budgets obtain from group-housed cats and from singly-housed cats observed in other studies (Podberscek *et al*., 1991; deMonte and LePape, 1997; Rochlitz *et al*., 1998; Eckstein and Hart, 2000b; Kry and Casey, 2007; Monk, 2008).

3.2. MATERIALS AND METHODS

Refer to Sections 2.2.1., 2.2.2 and 2.2.3 for descriptions of study site, subjects and data collection methodology.

3.2.1. Data Analysis

The activity of each cat was recorded by scan sampling method in 15-min intervals over the six-hour observation periods conducted each day. Due to the instantaneous nature of the sampling method, no cat interactions were observed in all the scans. Table 3.1 describes the five main categories of activity recorded: Nap, Idle, Groom, Walk, Others. Only three cats (each in a different room) were observed pacing (i.e. walking to and fro in a repetitive and predictable pattern), hence, pacing was included under Walk.

Table 3.1: Activities engaged by the cats

Activity	Description
Nap	Resting with the eyes closed and body lying down either on the side or on belly
Idle	Sitting or lying still, awake and alert with eyes open
Groom	Cat licks its own or another cat's fur
Walk	Any locomotion, includes pacing
Others	Drinking, eating, defecating, urinating

Pearson's Chi-square test was used to detect differences in activity budget between high and low density rooms, as well as between high and low complexity conditions. Where significance was detected, individual Chi-square tests were run for each activity.

3.2.2. Other studies

Activity budgets obtained from Mutts & Mittens and Pets Villa were compared with those obtained from six other studies (Podberscek *et al*., 1991; deMonte and LePape, 1997; Rochlitz *et al*., 1998; Eckstein and Hart, 2000b; Kry and Casey, 2007; Monk, 2008). However, each of these studies defined activity categories differently (e.g. the present study distinguished between true resting behaviour from alert rest while some of the studies did not), making direct comparison impossible. In order to best compare activity budgets across these studies, activity categories which correspond to the classification in this present study were combined and renamed accordingly. For instance, the categories "Moving", "self-play" and "object-play" described in de Monte & Le Pape (1997) were combined and renamed "Walking" to correspond with the activity categorization in this present study. Table 3.2 shows the original categories used in the respective studies and how they are renamed for analysis in this study. Whenever a study reported several activity budgets for different experimental setups, only the activity budget for which the experimental conditions best match those of the present study was used. For instance in de Monte & Le Pape (1997), activity budgets were obtained under three conditions: when cats were given a log, when cats were given a log and ball and when cats were not given log and ball. Only the activity budget for the control condition (when cats were not given the log and ball) was used.

Several differences in activity categories still exist among the studies after combining and renaming some categories. Hence, activity budget comparisons between the studies will be discussed generally instead of statistically analysed. Podberscek *et al* (1991)'s activity budget was excluded from the discussion as the study observed the cats using continuous sampling method but recorded activities as frequencies, thus failing to account for duration of prolonged activities such as resting and grooming.

Table 3.2: Original and renamed categories of activity defined in other studies

Original category	Renamed as
de Monte & Le Pape (1997)	
Inactivity	Nap
Still	Idle
Self-groom	Groom
Moving, self-play, object play	Walking
	Unaccounted
Eckstein & Hart (2000)	
Sleep/rest	Sleep/rest
Grooming	Grooming
Sitting/Playing/Moving	General activity
Eating/Drinking	Others
Kry & Casey (2007)	
Restful sleep	Nap
Alert rest and Sit	Idle
All other activities involving movement	Active
Monk (2008)	
Sleeping	Nap
Groom	Groom
Active on the floor	Walk
Eating	Others
	Unaccounted

Category "Unaccounted" was created for studies for which the reported time budget percentages did not add up to 100% and meant to stand for all activities other than those reported in the respective studies.

3.3. RESULTS

3.3.1. Mutts & Mittens

The activity budgets for each room in Mutts & Mittens are presented in Figure 3.3. Napping was the activity the cats engaged in the most in all observed rooms (58-67% of total observation time). There seems to be little variation between rooms with regards to time spent Idling (17-20%), Grooming (5-6%) and engaging in other behaviors (3-5%). Cats in Rooms A and C spent approximately twice the amount of time Walking (11-13%) than cats in Rooms B and D (5-6%).

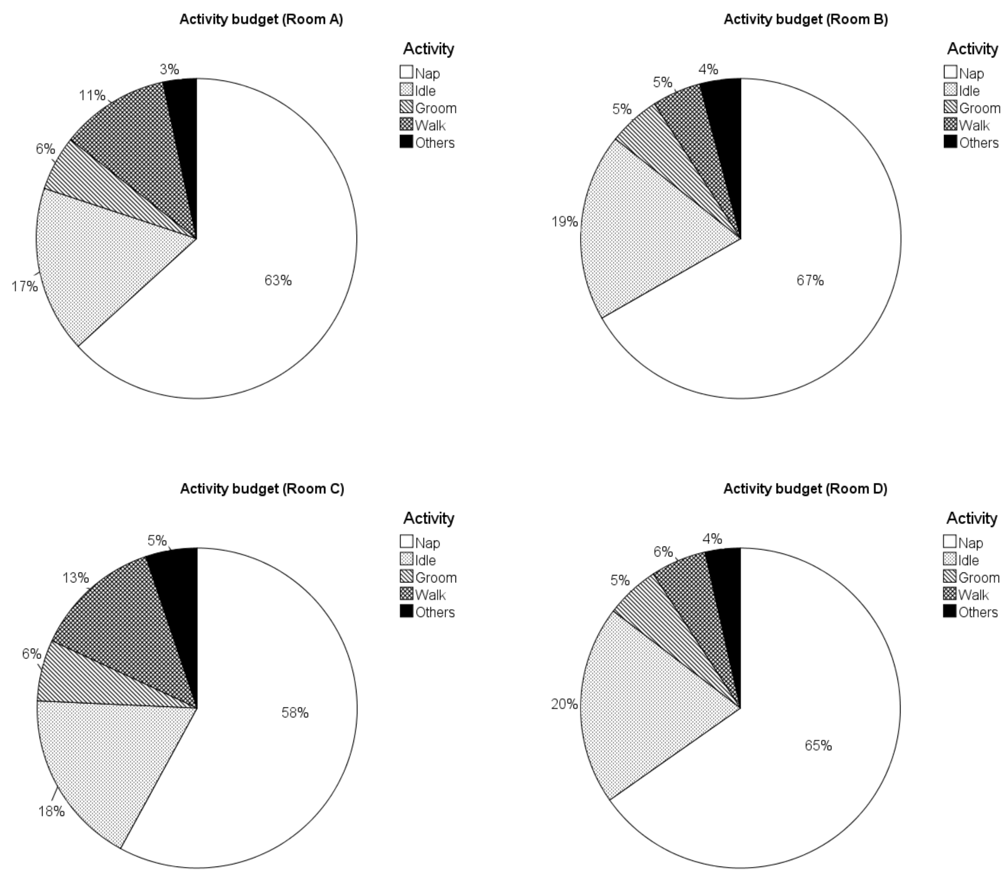


Figure 3.3: Activity budget for each room in Mutts & Mittens

3.3.2. Pets Villa

Pearson's Chi-square test revealed no significant difference in activity budget between the high density rooms (7 and 32) in the high complexity ($\chi^2 = 2.86$, $df = 4$, $P = 0.581$) and low complexity conditions ($\chi^2 = 19.873$, $df = 12$, $P = 0.07$) and among the low density rooms (9, 15, 19, 21) in the high complexity ($\chi^2 = 4.54$, $df = 4$, $P = 0.338$) and low complexity conditions ($\chi^2 = 2.017$, $df = 4$, $P = 0.733$). Hence, the data were pooled and average scores were used to analyze activity budget.

The activity budgets for cats in Pets Villa are shown in Figure 3.4. Napping was the most common activity observed in both high density (60% of observations) and low density rooms (67%) in high complexity conditions. Idling and grooming were observed 15-19% and 13-16% of the time respectively and walking was rarely recorded (1-2%). The remaining 3-4% of the observations recorded other activities. When enclosure complexity was reduced, the cats in both high density and low density rooms napped less (36% and 37% respectively), idled more (37% and 31% respectively), and groomed more (21% for both). 2-4% of the time was spent walking while the remaining 5-6% recorded other activities.

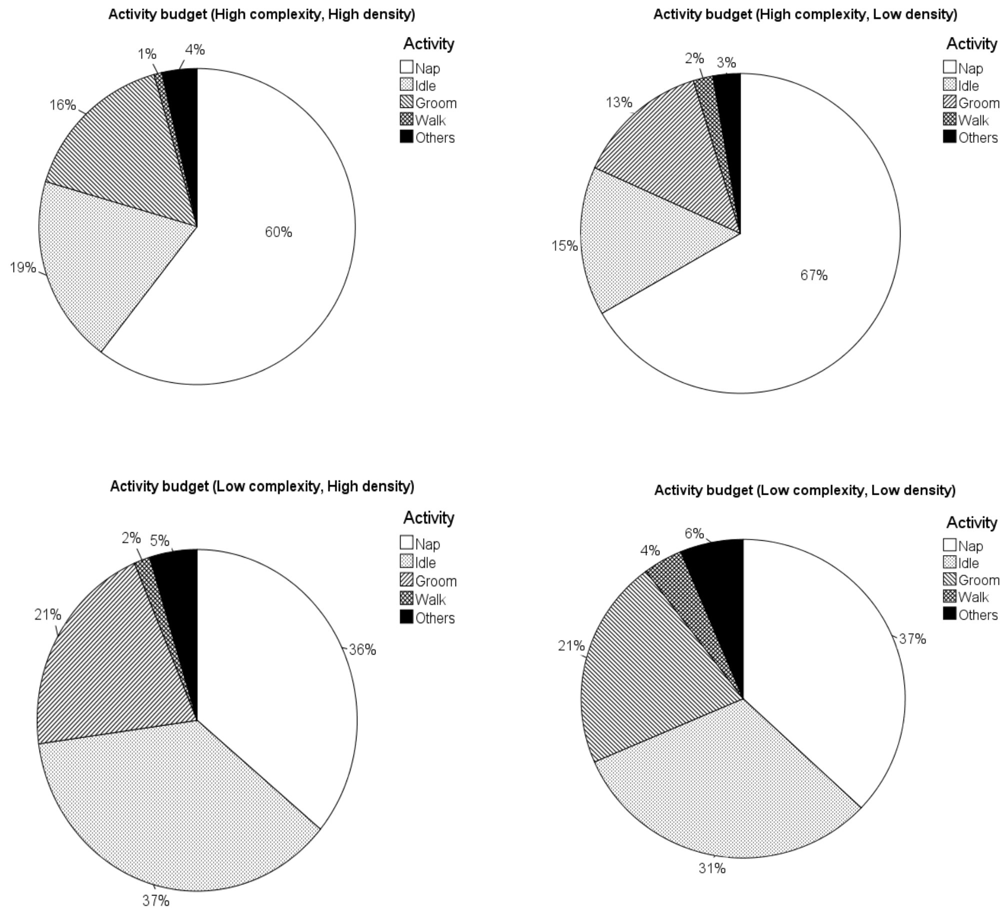


Figure 3.4: Activity budget (Pets Villa)

3.3.2.1. Effects of density

There is no significant difference in activity budget between high and low density rooms in both the high complexity ($\chi^2 = 4.08$, $df = 4$, $P = 0.395$) and low complexity conditions ($\chi^2 = 2.04$, $df = 4$, $P = 0.729$).

3.3.2.2. Effect of complexity

In the high density rooms, significant difference in activity budget was detected between high and low complexity conditions ($\chi^2 = 21.68$, $df = 4$, $P < 0.001$). Individual Chi-square tests on each activity revealed that cats napped less ($\chi^2 = 19.89$, $df = 1$, $P < 0.001$) and idled more ($\chi^2 = 13.74$, df

= 1, P < 0.001) under the low complexity condition. No differences were found for grooming (χ^2 = 1.32, df = 1, P = 0.25) and other activities (χ^2 = 0.313, df = 1, P = 0.576).

Activity budg*et al*so differed significantly between high and low complexity in the low density rooms (χ^2 = 34.63, df = 4, P < 0.001). Individual Chi-square tests on each activity revealed that cats napped less (χ^2 = 33.80 df = 1, P < 0.001), idled more (χ^2 = 15.60, df = 1, P < 0.001) and groomed more (χ^2 = 4.71, df = 1, P = 0.03) under low complexity conditions. No difference was found for other activities (χ^2 = 2.04, df = 1, P = 0.153). Chi-square tests could not be used for walking because walking was observed too infrequently.

3.3.3. Other studies

Activity budgets reported by other studies are shown in Figure 3.5. Rochlitz *et al* (1998) reported that the cats spent 32% of the time napping and 7.5% of the time grooming. The activity budget pie chart for that study was not provided since no other activities were observed and recorded. Cats studied in Monk (2008) were housed communally while cats in the remaining four studies were housed singly, or were videotaped while in individual cages before returning to their communal housing (Eckstein and Hart 2000).

De Monte and Le Pape (1997)'s study reported an activity budget for 10 singly-housed male cats (six months old) in terms of number of minutes engaged in an activity per 100 min. The cats spent 39% of the time napping, and the remaining time idling (19%), grooming (3%) and walking (7%). Eckstein and Hart (2000)'s study obtained an activity budget of group-housed cats by videotaping 11 individuals which were kept in individual cages during the observation. They were unable to distinguish between true napping behavior and alert rest and reported a 50% of the time budget to nap/rest behavior. General activity (comprised of sitting, exploring and playing) took up 43% of the time while the remaining time was spent grooming (4%) and eating/drinking

(3%). Kry and Casey (2007) observed 22 singly-housed cats and reported an activity budget, of which 20% of the total observation time was spent napping, 74% on idling (alert rest, sit) and the remaining 6% on activity (all other activities involving movement).

Monk (2008)'s research was the only study, apart from the present study, in which an activity budget was obtained from cats housed communally (three to nine cats per group, 24 cats in total). The study observed no "idling" (that is, alert rest) in the cats after the first two weeks of being admitted into the shelter. Monk (2008) reported a time budget of 58% for napping, 6% for grooming, 15% for walking and 4% for eating.

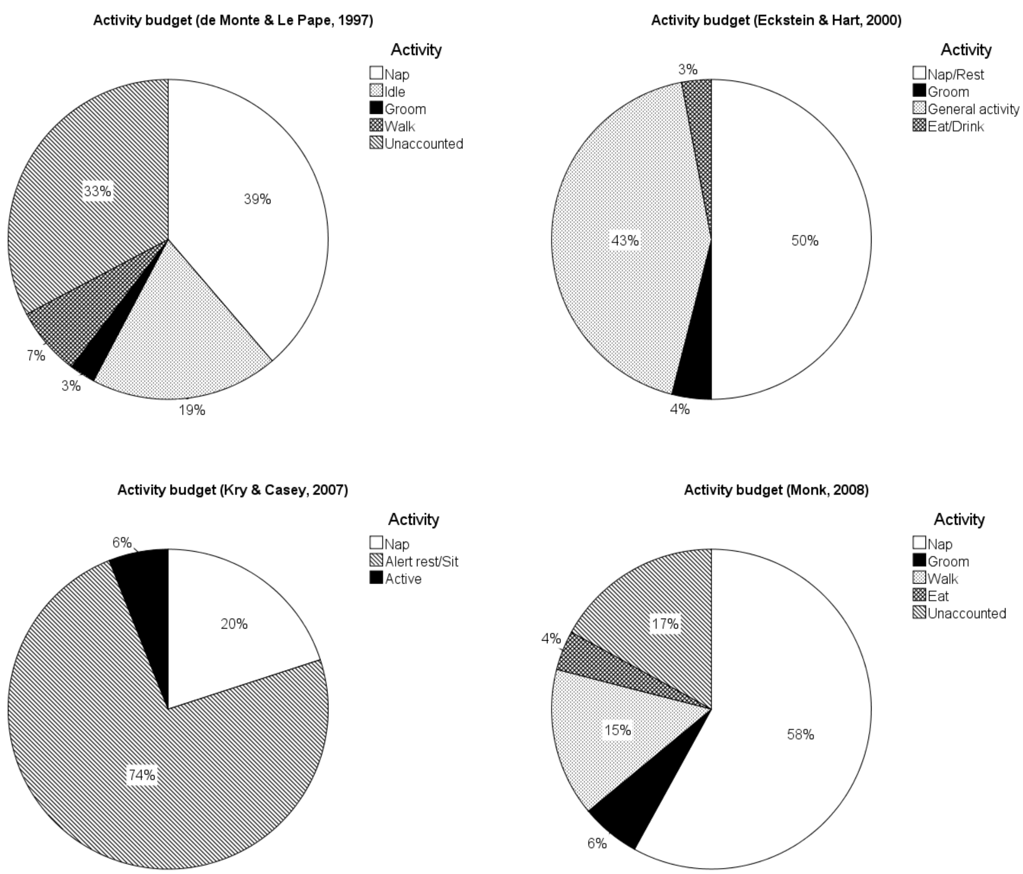


Figure 3.5: Activity budgets reported by other studies on confined cats

3.4. DISCUSSION

3.4.1. Napping and idling

In both animal shelters, the cats spent the most time engaged in napping behavior (58-67%) followed by idling (15-20%). It has been found that the average cat spends 65% of its time sleeping (Hart, 1978), while another study reported similar time budget for sleeping in cats housed communally (58%, Monk, 2008). A comparison of activity budgets obtained from several domestic cat studies (see Section 3.3.3.) reveals that cats housed singly in individual cages spend less time sleeping compared with cats housed communally. Although Eckstein and Hart (2000) reported that the cats spend 50% of time sleeping, this is inclusive of the time spent in alert rest, which implies that the time cats spent engaged in true sleeping behavior is well below 50% when cats are housed singly. The other three studies of singly-housed cats reveal low time budgets for sleeping of 20%, 32% and 39% respectively (deMonte and LePape, 1997; Rochlitz *et al*., 1998; Kry and Casey, 2007).

Some studies suggest that elevated sleeping is a result of stressful situations, where cats exhibit suppression of activity to avoid encounters and interactions with other con-specifics. For instance, Monk (2008) reported elevated time budget for sleep in cats newly introduced to a group-housing environment. It only returns to normal level after 8 months of boarding, suggesting the use of sleep as a coping mechanism for the stressful entry to a new environment. However, other studies have claimed the opposite that stressed cats sleep less but spend more time alert and hiding (Carlstead *et al*., 1993; Kry and Casey, 2007). This contradiction dissolves when distinction is made between true resting behavior and alert rest (in which a cat stays in one spot in a recumbent posture but remains vigilant and responsive to external stimuli). This distinction was made very clearly in the present study and it becomes apparent that under more stressful conditions (e.g.

Removal of resting structures in Pets Villa, Section 3.3.2.2.), cats spend less time in the truly napping behavior and more time in the alert rest. This reflects a suppression of activity, possibly for conflict avoidance (van den Bos, 1998; Crowell-Davis *et al*., 2004), and a predictable decrease in restful sleep in cats which are highly stressed. Smith and company (1994) also noted a similar increase in alertness by cats which are not yet adjusted to a new environment. The phenomenon that singly-housed cats spend less time sleeping than communally-housed cats implies that group-housing might be less stressful for domestic cats admitted to animal shelters.

Housing density does not seem to have an effect on the time budget cats spent on napping and idling (see Results, Section 3.3.2.1). This is not congruent with the prediction that cats in rooms with lower number of cats would spend more time sleeping and less time in alert rest relative to cats in rooms with more animals. Cats were predicted to spend more time in alert rest under high density conditions because vigilance has often been associated with anxiety induced by the presence of other unfamiliar cats. Beaver (1992) observed that a house cat will sit vigilant in an area which allows it to watch "intruders" inside or outside of the house. The absence of this phenomenon in the present study suggests that the cats have been acclimatized to the presence of others in the same room. This seems less surprising if we consider that most of the cats included in the study have been boarding with each other for at least a year, excluding two cats which have been removed to a quarantine area when they contracted flu and later allowed to rejoin the group less than two weeks prior to the observation period.

3.4.2. Grooming

Grooming took up 3 - 7.5% of the time budgets in cats housed in Mutts & Mittens, as well as those reported in other studies discussed in Section 3.3.3. However, cats housed at Pets Villa spent approximately twice as much time grooming (13-16%). The elevated grooming in Pets Villa may be due to a higher ectoparasite load in the shelter relative to Mutts & Mittens.

Grooming has been widely acknowledged for playing a role in controlling ectoparasite load (mites, fleas and ticks) from the pelage (Hart, 1990; Eckstein and Hart, 2000a). Indeed, grooming in impala is found to be positively correlated with adult tick challenge (Mooring, 1995) and flea exposure is reported to increase grooming in cats (Eckstein and Hart, 2000a). The significance of grooming in reducing ectoparasite load has also been demonstrated with the use of harness or restraining collars (e.g. Elizabethan collars) on cattle and cats. When cattle is prevented from self-licking, more ticks survive to engorgement than ticks found on cattle which are allowed to lick freely (Snowball, 1956). Similarly, cats fitted with Elizabethan collars (which prevent auto-grooming) are found to have more fleas than cats which wore control collars which do not prevent auto-grooming (Eckstein and Hart, 2000a). Mice which are prevented from oral grooming also show excessive louse infestation 60 times the normal level (Murray, 1987) while prevention of grooming is found to influence tick loads in impala (Mooring *et al*., 1996).

This present study reports elevated grooming in Pets Villa relative to Mutts & Mittens, and suggests that the cats housed in Pets Villa may be under higher ectoparasitic stress than those housed in Mutts & Mittens. Another study reported that cats which are exposed to fleas spend about twice as much time oral grooming than cats in a flea-free environment (Eckstein and Hart, 2000a). Although no direct investigation was conducted to check if the prevalence of fleas is higher in Pets Villa than in Mutts & Mittens, several evidences suggest indirectly that this might be so. Firstly, the housing condition in Pets Villa seems more conducive to flea breeding. Flea larval development occurs in microhabitats which have moderate temperature and high relative humidity (Dryden and Rust, 1994). The cat-housing rooms in Pets Villa are constructed very close to each other such that air does not circulate freely in the inner parts of the cat compound. By contrast, rooms in Mutts & Mittens are arranged in rows which are spaced sufficiently away from each other and allow good ventilation. Hence, the microenvironment in Pets Villa may have higher relative humidity than that in Mutts & Mittens, and consequently results in higher prevalence of fleas in the former shelter. Secondly, a separate study has shown that the fleas are transmitted primarily in the pupae which are shed mostly at cat resting sites (Beck and Stickel, 2008). At Mutts & Mittens, few resting structures are provided and cats are mostly observed to rest on the concrete floors which are washed daily. Pets Villa, on the other hand, provides more resting structures like hammocks, cloth-lined baskets and bedding. Although floors and shelves are washed daily, resting structures are usually unwashed and might be potential transmission grounds for fleas at the shelter. Finally, several owners who boarded their cats in Pets Villa have complained about the presence of fleas and mites in their cats while no such complaints were heard from cat owners who admitted their cats to Mutts & Mittens. This study recommends that time budget for grooming could be used to monitor prevalence of fleas, and that animal shelters should ensure proper ventilation when setting up boarding rooms and take special care in decontaminating resting structures regularly to reduce flea infestation.

Apart from the already elevated amount of grooming in cats housed at Pets Villa, a further increase in grooming was observed when the furniture was removed from the rooms to simulate a low enclosure complexity condition (See Section 3.3.2.2.). This suggests that a low complexity condition is stressful to group-housed cats, since stress has been shown to induce excessive grooming in cats (Willemse and Spruijt, 1995). The increase in grooming was only observed in low density rooms but not high density ones, suggesting that crowding may favor sleeping over grooming as a coping mechanism for stress.

3.4.3. Walking

In Mutts & Mittens, cats in Rooms A and C spent twice the amount of time walking (11% and 13% respectively) relative to cats in Rooms B and D (5% and 6% respectively). Rooms A and C are located in the first row of rooms (nearer to the main office and the entrance) while Rooms B and D are among the second row of rooms. Visitors tend to tour the first row of rooms more often and watch the cats for longer periods while they might forgo touring the second row of rooms altogether (personal observation). Since cats tend to approach the front of the rooms whenever there are visitors, it is not surprising to find more walking behaviors in Rooms A and C.

In Pets Villa, walking was observed very infrequently (1-4% of the observations). Only three cats (each from different rooms) were observed to pace (that is, to walk to and fro in a repetitive and predictable pattern). Pacing is considered one of the most common stereotypic behaviors seen in wild captive carnivores and is often linked with poor welfare. Since the pacing was always observed just before feeding time, it is tempting to regard this pre-feeding pacing as a harmless version of normal hunting instead of putting a label of poor animal welfare on the shelter housing conditions, especially since it is exhibited by a rare exceptional few. However, it should be noted that pacing was entirely absent in Mutts & Mittens and, hence, should be regarded as a serious matter of investigation to examine the cats' welfare in Pets Villa.

3.5. CONCLUSION

Investigation of activity budget is important as it gives us insight into the livelihoods of confined animals, from which we may understand coping mechanisms, monitor stress levels and mitigate ill-welfare practices. Domestic cats spend most of the day sleeping but under stressful conditions (e.g. being housed singly, or in low complexity enclosures), they spend less time in truly resting behavior and more time vigilant. Elevated grooming may also indicate higher ectoparasite loading and stress. Walking was observed infrequently and usually in response to visitor disturbance. However, pacing behavior was exhibited by three cats in Pets Villa, and should be treated as an abnormal stereotypic behavior. Further investigation is needed to pinpoint specific aspects of poor welfare in the animal shelter.

CHAPTER 4

SPACE USE AND SPACE SHARING BEHAVIOUR IN GROUP-HOUSED DOMESTIC CATS (*FELIS SILVESTRIS CATUS*)

ABSTRACT

Animals in enriched captive environments exhibit preference for some structures over others. An understanding of enclosure space use can give an indication of the appropriateness of the enclosure design and provide useful information on how to improve it to better the welfare of captive animals. This study investigated the type of "spots" favoured by cats housed in animal shelters and described how the groups of cats would share the limited enclosure spaces. I also examined whether dominant and submissive cats differed in the types of "spots" they favoured. Four main space sharing behaviors were also described in this study: avoidance, temporal sharing, tolerance and positive association. I also determined the effect of several factors (housing density, dominance of cat, sex and weight difference in a dyad) on the type of sharing employed. Results revealed that the cats strongly "favoured" elevated and closed spots such as shelves and baskets. Cats which were subjected to aggression by other cats were less likely to be found on the ground and in "open spots" compared to those which are not subjected to aggression. Same-sex dyads were less likely to employ tolerance and positive association than different-sex dyads while a pair of submissive cats was more likely to employ these sharing mechanisms than a pair of dominant-submissive cats. Whenever sufficient resting structures were provided, cats were also found to prefer avoiding resting with each other (unless they are affiliates) or to temporally share the highly preferred structures. These results point to the importance of providing ample resting structures at elevated spots for cats in animal shelters.

4.1. INTRODUCTION

The use of enclosure space in captive animals has been widely studied, particularly for primates (Stoinski *et al*., 2001; MacLean *et al*., 2009; Ross *et al*., 2011). These studies found that in a heterogeneous zoo enclosure, the animals exhibit varying preference for different structures, substrates and spaces provided. For instance, chimpanzees are found to utilize vertical spaces more while lowland gorillas prefer to rest on the floor (Ross and Lukas, 2006), and to stay close to walls and fences more often than being in open spaces (Stoinski *et al.*, 2001). Captive felids are also found to use the edges of their enclosure for pacing while resting spots are located in the inner parts of the enclosure (Lyons *et al.*, 1997). Understanding an animal's space use can thus give us insight into the appropriateness of an enclosure design, and consequently allow us to make inferences on the welfare of the captive animals (Ross *et al.*, 2009).

For the domestic cat, many reports recommend that they should be provided with ample resting spots at elevated positions, (AWR, 1985; Rochlitz, 1999; Ellis, 2009). It is reported that cats spend more time on elevated places, and it is suggested that such elevated spots function as "vantage points" from which stressed cats are able to maintain surveillance of the surrounding and to prevent unexpected "attacks" from other individuals in a group-living condition (DeLuca and Kranda, 1992; Holmes, 1993; James, 1995). Another study also observed that lower-ranking cats tend to flee to an elevated "complex" from higher-ranking cats (van den Bos and Buning, 1994). However, this is merely speculation, and whether or not vantage points really afford protection from attacks is unknown. If it is true that cats use elevated spots as "vantage points", cats which are subjected to more "attacks" would be expected to spend more time in elevated spots relative to cats that are not "attacked". This study aims to test this hypothesis.

Cats are also more likely to rest alone than with others (Podberscek *et al*, 1991), and are found to spend about 50% of the observed time out of each other's sight (Barry and Crowell-Davis, 1999). Hence, it is also highly recommended that there should be resting areas where cats can retreat to and be concealed, such as high-sided cat beds and boxes (Rochlitz, 1999; Overall *et al*., 2005). Schroll (2002) recommends that each cat should be given two types of resting places, one on the floor with three sides enclosed and another elevated with a good view of the rest of the room. Such concealing spots reduce the surface area a cat is exposed to approach by other cats and may be "favoured" for the protection they provide. This study predicts that cats which are subjected to more "attacks" by others will strongly prefer elevated spots and/or "closed spots" which conceal the cats.

Besides investigating the structural preference of captive animals, understanding how a group of confined animals share the limited enclosure space is also critical for assessing their welfare. Studies on whether or not captive animals should be housed in groups generally focus on investigating how group-living will affect the behavior and stress levels of the animals (De Rouck *et al.*, 2005) and their social interaction (Yoerg, 1999; Genin, 2010). However, few explicitly discuss the issue of how animals share a limited enclosure space. Some studies of indoor-cats attempt to examine how they utilize a home base, but all of them discuss very generally how cats spend most of their time out of each other's sight but are observed to share the space temporally (Bernstein and Strack, 1996; Crowell-Davis *et al*., 2004; Crowell-Davis, 2007). The lack of detail is probably due to the use of the scan sampling method, where locations of cats are noted every 10 minutes or so (van den Bos and Buning, 1994). The present study conducted a detailed tracking of the space use of every individual cat throughout the observation period and was able to capture more information on how confined cats share space in animal shelters. This study is also the first to investigate how housing density, enclosure complexity, sex, dominance and weight of the cats might affect the space sharing behavior the cats employ.

4.2. MATERIALS AND METHODS

Refer to Sections 2.2.1., 2.2.2 and 2.2.3 for descriptions of study site, subjects and data collection methodology. For all purposes of recording cat locations, the enclosure was divided into distinct "spots". Appendix B shows the enclosure sketches (not drawn to scale) of the rooms selected for observation. The sides of room were distinguished from center of room. A cat was considered to be resting at the "Sides" if it was found resting against the fence, or within 0.5m of the perimeter (approximately one cat body length). Each discrete resting structure (e.g. Basket, carrier) was considered a separate spot. Each tier on the shelves provided was considered a separate spot.

4.2.1. Favoured spot

The total number of hits a cat was observed in a particular spot was obtained from the scan samples. A spot was considered a "favoured spot" if the cat was observed in the spot for more times than is expected. The expected value was calculated using binomial test, with the null hypothesis stating that if a cat does not favour any spot above others, it should be observed equally in all the available spots in the enclosure.

For purposes of statistical analysis and discussion, spots were grouped together according to whether they are elevated or on the ground, and whether they "closed" or "open". A spot was considered closed if when a cat rested in that spot, at least one of its sides is close to a structural barrier such that another cat cannot approach it from that side (e.g. side of room). An open spot was one in which a resting cat can be approached from all sides by other individuals in the room. All spots were categorized in this manner into three "spot types": "Elevated, closed", "Ground, closed" and "Ground, open". Elevated, closed spots include baskets, shelves, ledge, carriers and top of chairs/cage. Ground, closed spots include “sides of room”, underneath a chair and inside litter boxes. Ground, open spots include all ground spots found in the center of the room.

To investigate if dominance of the cat (See Section 2.2.4.1. on how dominance was defined) affected the type of spots they favoured, the frequency each cat was observed in each of the three spot types was averaged for dominant cats and for submissive cats. Pearson chi-square test was used to detect any differences in the scores between dominant and submissive cats. Each room was analysed separately because dominance was a relative measure in this study (i.e. a dominant cat in one room may not necessarily be dominant in another room).

4.2.2. Space sharing behaviour

This was only investigated in Pets Villa because Mutts n Mittens did not allow for manipulation of boarding rooms (to simulate different enclosure complexities). Four behaviours for space sharing were defined according to three criteria: (i) whether or not a pair of cats was seen resting close together, (ii) if they were never observed resting together, do they share at least one common favoured spot, and (iii) if they have been observed resting together, are they affiliates (See Section 2.2.4.2. for definition of Affiliation). A pair of cats was considered to be resting close to each other if they are resting within 0.5 meters of each other. The four sharing behaviours were defined as follows: (i) Avoidance – cats were never seen resting together and do not share any “favoured spot”, (ii) Temporal sharing – cats were never seen resting together but shared at least one “favoured spot” temporally, (iii) Tolerance – cats were seen resting together but are not affiliates and (iv) Positive association – cats were seen resting together and are affiliates. A pair of cats were also considered to have exhibited temporal sharing if (i) a cat leaves a resting spot on its own and another cat immediately takes the vacated spot, (ii) a cat stares/supplants/approach another cat, causing it to move away from a resting spot before taking over, (iii) a cat resting at a spot prevents another cat from joining it by staring/meowing/pawing and (iv) a cat wants to rest at a particular spot, sees another cat resting there, turns to rest somewhere else instead. The predominant type of sharing behaviour was determined for all pairs of cats in each room.

The four behaviours described above exhibited an increasing level of affiliation with avoidance being the least affiliative and positive association the most affiliative type of sharing. Hence, an ordinal logistic regression was used to analyse the effects of several factors on the type of space sharing behaviour predominantly seen. The factors investigated were: (i) Housing density (continuous), (ii) dominance of cat (categorical), (iii) sex of cats in a pair (same sex, or different sex) and (iv) weight difference between the two cats. To investigate effect of enclosure complexity on the type of sharing behaviour exhibited, Pearson chi-square test was used to detect differences in the average number of dyads exhibiting each type of sharing behaviour between high and low complexity conditions.

4.3. RESULTS

4.3.1. Favoured spot

When cats were provided with resting structures like baskets and shelves, the type of spot the cats favoured was investigated. Composition of all favoured spots for Pets Villa was shown in Figure 4.1. Most of the spots which were favoured by the cats were elevated and closed (75%). They comprised of shelves/ledge (37%), baskets (26%) and top of stool/cage (12%). The remaining 25% of the favoured spots comprised of ground (side) (20%), ground (center) (3%), bottom tier of shelves (1%) and underneath the chair (1%). When comparing total number of observations recorded, 26 out of 34 cats were found on elevated spots more often than on ground spots (76.5%) while only eight cats (23.5%) were observed to be on the ground more than on elevated spots. All of these eight cats were housed in high density rooms, two of which were subjected to aggressive acts by others and the remaining six were not subjected to aggressive acts.

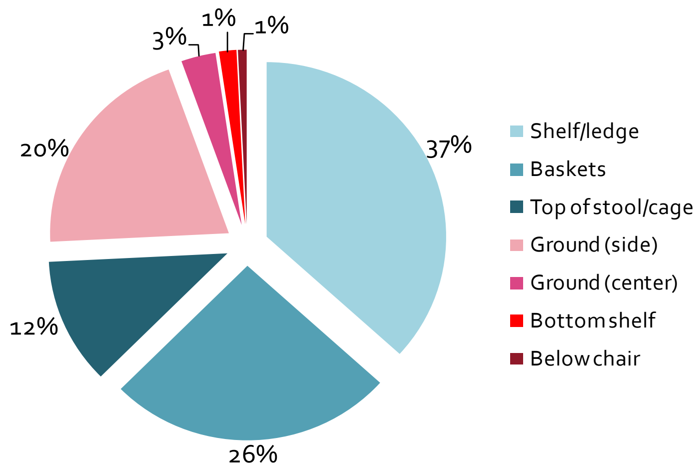


Figure 4.1: Composition of all favoured spots (Pets Villa)

For Mutts & Mittens, the composition of favoured spots was presented graphically in Figure 4.2. 69% of the favoured spots were of the Ground, closed type, 29% were Elevated, closed spots and the remaining 2% were Ground, open spots.

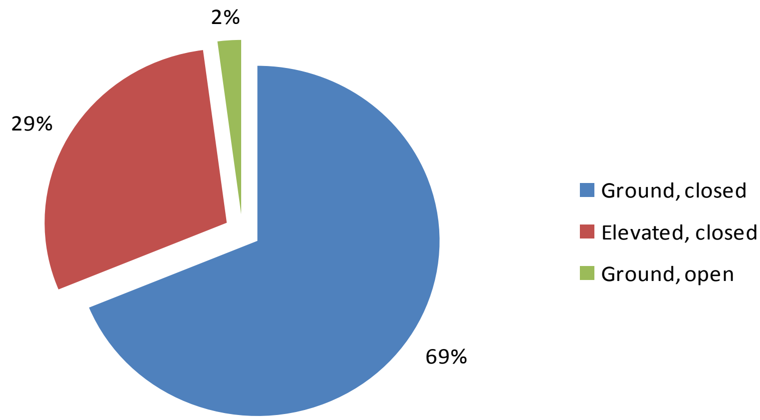


Figure 4.2: Composition of all favoured spots (Mutts & Mittens)

Under low complexity conditions (where baskets and shelves are removed from rooms 7, 8, 9, 19, 32), the cats could only rest on the ground. Whether or not the cats favoured "sides" or "center" as resting spots was investigated. 22 out of 27 cats (81.5%) were found on the sides of the room more often than in the center. The remaining five cats were observed resting in the center more often than on the side. All cats that were observed to rest in ground, center spots were housed in rooms which are generally affiliative (Appendix D). Composition of all favoured spots under low complexity condition was shown in Figure 4.3. Most of the favoured spots were Ground, side (69%) while the remaining favoured spots comprised of Ground, center (20%), "Ledge" (10%) and "inside litter box" (1%).

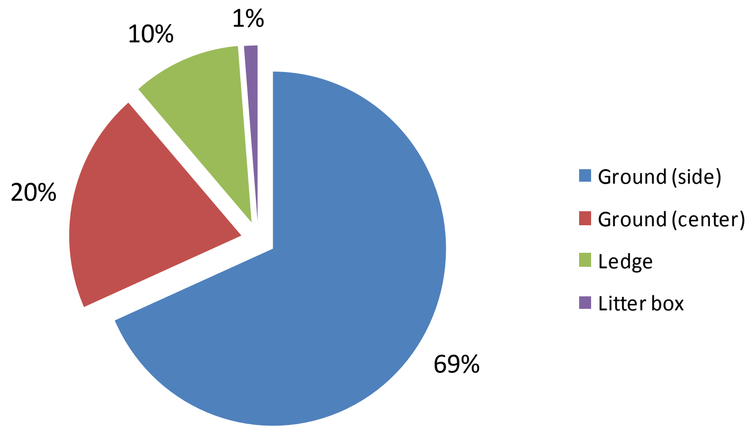


Figure 4.3: Composition of favoured spots under low complexity condition (Pets Villa)

4.3.2. Effect of dominance

The prediction that dominant and submissive cats were observed at different frequencies at different spot types was tested. The average number of times the cats were observed in each spot type for dominant and submissive cats was shown in Table 4.4. Pearson chi-square test was used to detect any differences between dominant and submissive cats in each room separately. The results showed that dominant cats differed significant from submissive cats in the number of times they were observed in the different spot types only in Rooms 7 ($\chi^2 = 18.31$, df = 2, P <0.001) and 8 ($\chi^2 = 13.25$, df = 2, P = 0.001), but not in Room 32 ($\chi^2 = 5.9$, df = 2, P = 0.052). The difference between dominant and submissive cats in the percentage of time they were observed in each spot type was shown graphically in Figure 4.5. In Room 7, dominant cats were found significantly more often on ground, open spots than submissive cats while submissive cats were found more often in ground, closed spots than dominant cats are. In Room 8, submissive cats were found more often in elevated, closed spots and less often in ground, closed spots compared to dominant cats. In Room 32, dominant and submissive cats did not differ significantly in the type of spots they were found in.

Table 4.4: Average number of times the cats are observed in each spot type

	Spot Type		
	Elevated, closed	Ground, closed	Ground, open
Room 7			
Dominant cats	64	35	33
Submissive cats	76	48	8
Room 8			
Dominant cats	78	59	7
Submissive cats	107	31	7
Room 32			
Dominant cats	82	34	9
Submissive cats	81	24	20

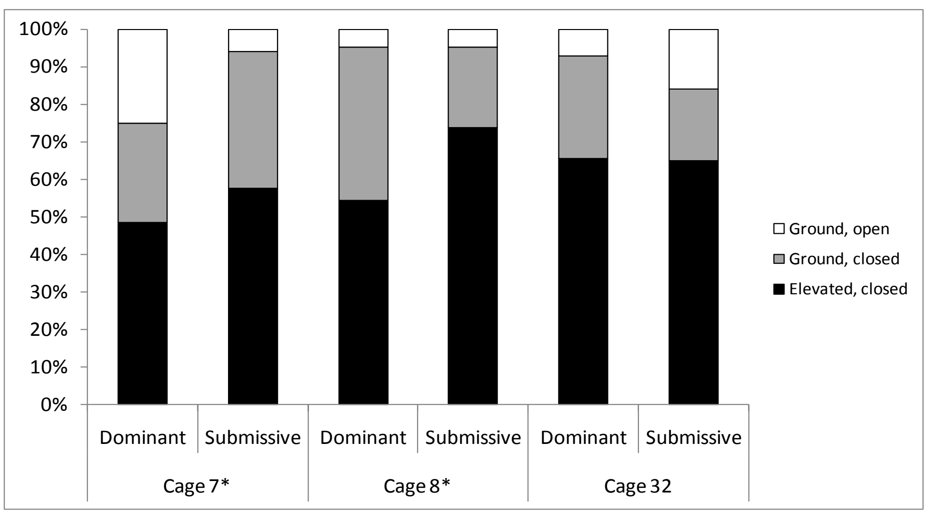


Figure 4.5: Percentage of observations the cats are found in each spot type. * indicates there is significant difference between dominant and submissive cats in that room.

4.3.2. Space sharing behaviour

33 out of 79 dyads employed avoidance, 26 employed temporal sharing, nine employed tolerance and the remaining 11 dyads employed positive association. Ordinal logistic regression was used to analyze the effect of various factors on the type of sharing employed. Housing density and

weight difference between a pair of cats did not affect the type of sharing behavoiur they exhibited but sex and dominance of the cats influenced the type of sharing (Table 4.6). The results state that relative to dyads of different sex cats, in a same-sex dyad, we expect a -1.726 increase in the ordered log odds of being in a higher level of sharing, given that all of the other variables are held constant. It also states that relative to dyads of submissive cats, in a dyad comprising of a dominant and a submissive cat, we expect a -1.182 increase in the ordered log odds of being in a higher level of sharing, given that all of the other variables are held constant.

Table 4.6: Results of ordinal logistic regression analysis on effect of housing density, dyadic weight difference, sex and dominance of cat on the type of sharing behaviour observed

Variable	**Estimate**	***p* value**
Density	-1.126	0.348
Weight Difference	-0.214	0.579
Sex	-1.726	0.002
Dominance	-1.182	0.043

4.3.2.1. Effect of housing density

Although housing density was not found to significantly affect the type of sharing behavious observed, some interesting trends can still be identified. Figure 4.7 shows the percentage of various sharing behaviours observed and how cats in high density rooms differed from those in low density rooms. In general, cats in high density rooms were more likely to exhibit avoidance while cats in low density rooms were more likely to show temporal sharing. Cats in low density rooms also tended to employ positive association relative to cats in high density rooms.

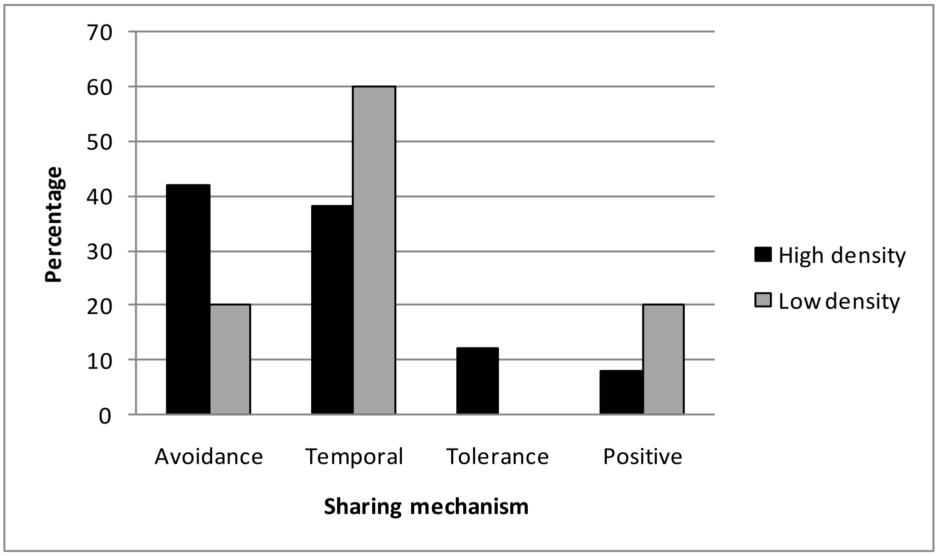


Figure 4.7: Percentage of various sharing behaviours observed

4.3.2.2. Effect of enclosure complexity

Pearson chi-square test revealed significant difference in type of sharing used between high and low complexity conditions. The number of dyads exhibiting the various sharing behaviours, as well as the results of the chi-square test, was tabulated in Table 4.8. Relative to low complexity condition, cats housed in high complexity conditions were significantly more likely to employ avoidance ($\chi^2 = 16.2$, $df = 1$, $P < 0.001$; Table 4.8) and temporal sharing ($\chi^2 = 12.57$, $df = 1$, $P < 0.001$; Table 4.8) but less likely to show tolerance ($\chi^2 = 36.25$, $df = 1$, $P < 0.001$; Table 4.8). No difference was detected for positive association between high and low complexity conditions ($\chi^2 = 0.056$, $df = 1$, $P = 0.81$; Table 4.8).

Table 4.8: Number of dyads exhibiting the various sharing behaviours under different complexity conditions and results of Pearson chi-square test

Cage condition	**Sharing type**			
	Avoidance	Temporal	Tolerance	Positive association
High complexity	26	23	11	10
Low complexity	6	6	46	12
χ_1^2	16.2	12.57	36.25	0.056
p **value**	**<.001**	**<.001**	**<.001**	0.81

4.4. DISCUSSION

4.4.1. Favoured spot

A majority of the cats were observed on elevated spots more often than ground areas (76.5%), and correspondingly, 75% of all favoured spots were of the elevated, closed type (i.e. shelves, baskets, top of chairs/cages). In Pets Villa, only eight out of 26 cats were observed on the ground more often than on elevated spots. However, it should be noted that all of these cats were housed in rooms with higher number of cats. Hence, it is possible that all the elevated spots were occupied by other individuals and that these eight cats “had no choice” but to rest on the ground areas. When cats were housed at low densities, all of them favoured elevated spots over ground spots, implying that whenever elevated spots are available, cats preferred to rest in these areas. This preference for elevated spots has already been demonstrated in other studies (DeLuca and Kranda, 1992; Holmes, 1993; James, 1995).

It has been suggested that cats preferred elevated places because they provide “vantage points” for cats to monitor their surroundings. A separate study reported that captive tamarins preferred nesting boxes that hid them from view of others, that were high up in the enclosure, and that provided them with overhead cover (Caine *et al*., 1992). From this, we expect that all cats that are frequently subjected to aggressive acts by other cats would favour elevated spots and avoid the ground where most interactions occur. This study reports that out of the 12 cats that were subjected to aggression (i.e. pawing, staring, chasing, biting), only one cat was observed to favour ground spots over elevated spots. It should also be noted that this cat was easily disturbed by the presence of others (observed to leap away from resting spot when another cat approaches to within 1 meter from it) and had been seen pacing the front of the room for long periods of time after being displaced from rest. It appears that this cat could not "defend" its position when it chose an elevated resting spot, and could explain why it was observed to favour ground spots over elevated ones, despite being subjected to aggression. In line with the "vantage point hypothesis", the remaining seven out of eight cats observed to favour ground spots were cats which were not subjected to aggression. Dominance rank seems to be irrelevant as four of them were submissive cats. The observations in this study suggest that cats that are subjected to aggression tend to prefer elevated spots while cats that are not subjected to aggression are more likely to use ground spots should the elevated spots be unavailable to them.

In Mutts & Mittens, a different trend is observed. Out of the 13 cats that are subjected to aggression, only two were observed to favour elevated spots. It should be noted that shelves and hanging baskets were not provided in this animal shelter. Instead, elevate spots consisted of a platform fixed 1.05 meters above the ground around three sides of the room and a wooden beam across the front of the room at a height of 2.40 meters. The wooden beam may not be favoured by the cats as a resting spot because it was not wide enough for a cat to rest comfortably on its side. They were used only by cats that were unsocialized to the presence of humans to avoid contact with the cleaner when he entered the room. The platforms were also under-utilized because they do not offer visual barriers (i.e. cats resting on the platforms are in full view of each other). Cats were often seen staring at another cat resting on the platform, causing it to jump down and rest elsewhere (personal observation). Perhaps it was this lack of appropriate elevated resting spots that resulted in a slightly higher frequency of aggressive behaviors in this animal shelter relative to Pets Villa.

Another notable trend is the phenomenon that under low complexity conditions (where shelves and baskets are unavailable), cats were observed to favour resting at the sides of the room over the center. This is widely known as the “open arena effect”, where confined animals tend to prefer resting close to barrier structures like walls, fences, and other structures. This phenomenon has been demonstrated in mice (Gray *et al*., 2000), captive lowland gorillas (Stoinski *et al*., 2001) and chimpanzees (Ross and Lukas, 2006). It is suggested that animals prefer resting next to solid structures because it confers a level of protection from any agonistic approach by others in the enclosure. In the present study, only five out of 27 cats were observed to favour center spots over the sides of the room. Interestingly, the rooms in which these five cats are housed were considered “generally affiliative” (i.e. a majority of all dyadic relationships in those rooms were found to be affiliative as opposed to agonistic). This suggests that only when cats are generally affiliative to each other in a room, and are subjected to few agonistic encounters, are they more likely to favour open resting spaces. But when cats are housed in a “generally agonistic” room, they are found to strongly favour resting at the sides of the room than at the center. This also points to the importance of providing structural barriers in an enclosure for better welfare of the cats, especially in rooms where cats are generally agonistic to each other.

Dominance of cat was found to significantly affect the type of spot favoured by the cats in Rooms 7 and 8 but not in Room 32 (See Section 4.3.2.). However, no general conclusions can be inferred from the results as the effect of dominance appears to be inconsistent across all three rooms. Although the results suggest that submissive cats tend to be found in ground, closed and elevated, closed spots more often than dominant cats, they do not allow accurate prediction of the type of spot a cat will favour based on its dominance status. As discussed above, the frequency a cat is subjected to aggressive acts appears to be a better predictor of its preference for elevated and closed spots. This might be due to the strange phenomenon observed in this study: several submissive cats were not subjected to aggression and were able to rest in ground, open spots for prolonged periods of time without being disturbed by others in the room. This might be a sign that the cats had become very well accustomed to group-living conditions in the shelter such that agonistic displays were no longer needed to establish rank or territory (Crowell-Davis *et al*., 2004).

4.4.2. Space sharing behaviour

Cats have been shown to prefer resting alone than with others (Podberscek *et al*, 1991). This study reports that 59 out of 79 possible dyads (74.6%) were never seen resting together, preferring instead, to avoid each other completely, or to share the enclosure space temporally. Nine dyads (11.4%) were non-affiliates but were observed to rest close to each other, suggesting that when cats are forced into close proximity with strange cats for a long time, they are able to adapt and be tolerant to each other's presence. 11 dyads (13.9%) had even forged an affiliative relationship in which two unrelated cats shared the enclosure space amiably and had been occasionally observed to curl up against each other while resting (Crowell-Davis *et al*., 2004).

This is the first study to investigate if the housing density, sex, dominance and weight difference in a dyad affects the type of sharing behaviour exhibited. It was found that only the sex and dominance of the cats had significant effects. The logistic regression analysis revealed that male-female pairs were more likely to employ tolerance and positive association (higher level of affiliative sharing) than male-male or female-female pairs, which were more likely to employ avoidance and temporal sharing mechanisms. This suggests that unrelated, same-sex con-specifics might be less tolerant of each other due to male-male or female-female competition. A similar phenomenon was also documented in another study on captive ferrets (Medina-Vogel *et al*., 2000). The study reported that male-female pairs more often used the same den at the same time than did male-male and female-female pairs. Dominance of the cats in a dyad was also found to affect their sharing behaviours. The results showed that when both cats in a dyad were both submissive, they were more likely to employ tolerance and positive association than a pair of cats in which one was dominant while the other was submissive. This was because most of the agonistic interactions occur between a dominant and a submissive cat. For instance, a dominant cat is more likely to supplant a submissive cat from a resting spot, causing the submissive cat to move away and rest at another spot. Furthermore, since such encounters are usually stressful (van den Bos, 1998), submissive cats tend to avoid dominant cats as much as possible. In contrast, displays of dominance are less likely to occur between two submissive cats. Hence these pairs would be more likely to exhibit the more affiliative space sharing behaviours. Other studies have also shown that the further apart the animals are in rank, the smaller the proximity scores (Judge and de Waal, 1993; van den Bos and Buning, 1994). A pair of submissive cats was also more likely to employ tolerance and positive association than a pair of dominant cats because the latter pair tends to exhibit more aggression towards each other. A study which observed three groups of four cats reported a tendency for more aggression to be evidenced when they put the most dominant cat of each group together (Baron *et al*., 1957).

4.4.2.1. Effect of density

Although the effect of housing density on space sharing behaviours was not found statistically significant, some interesting trends were observed. In general, cats in high density rooms were more likely to use avoidance while cats in low density rooms were more likely to use temporal sharing. The higher chance of employing temporal sharing implies that there is greater overlap in the favoured spots among the cats housed in low density rooms relative to those in high density ones. That is, the cats favoured the same spots (mostly shelves and baskets) and were “rotating” the use of these spots with each other over time. This was less prevalent in high density rooms because cats in these rooms tended to “stick to” their individual favoured spots and were less likely to rotate around. That is to say, it is often easier to predict where a cat in a high density room would be located than a cat in a low density room. This higher tendency to “stick to its own spot” suggests that a conflict avoidance mechanism exists under crowded housing conditions. The positive correlation between housing density and aggression has been demonstrated in mice (Van Loo *et al*., 2001), macaques (Boyce *et al*., 1998) and baboons (Elton and Anderson, 1977), and the present study also observed higher frequency of agonistic encounters in high density rooms. This study suggests that domestic cats may be inhibiting their use of favoured spots of other cats in order to avoid unnecessary conflicts than is already inevitable under crowded housing.

The results also show that cats in low density rooms are more likely to employ positive association. This suggests that crowding may inhibit social activities, such as resting together, even though housing density was found to have no significant effect on the level of affiliation in the cats (See Section 2.3.2.). Another study also reported that crowding inhibits social behavior (e.g. allo-grooming) in chimpanzees (Aureli and DeWaal, 1997). The absence of any tolerance in low density rooms also implies that only affiliates will choose to rest together. The converse is also true – that in high density rooms, non-affiliate pairs are tolerating each other’s presence. Whether the cats are exerting a “choice” in tolerating a non-affiliate cat or are “forced” to do so cannot be determined. However, it is important to conduct further investigation into this matter, since the welfare of an animal in captivity depends a lot on its ability to exert control over its surroundings (Morgan and Tromborg, 2007; Ellis, 2009). It is hence, highly recommended that animal shelters should provide ample choice in resting spots to ensure the welfare of the cats.

4.4.2.2. Effect of enclosure complexity

The effect of enclosure complexity on space sharing behaviours was investigated by removing shelves and baskets from the rooms to simulate a "low complexity" condition. Pearson chi-square tests revealed that relative to low complexity condition, cats housed in high complexity conditions were more likely to employ avoidance and temporal sharing but less likely to employ tolerance. The results suggest that cats generally avoid tolerance (that is, resting together with non-affiliates) but gravitate towards avoidance when they are provided with sufficient resting structures (Crowell-Davis *et al*., 2004). Positive association was not affected by enclosure complexity. This suggests that the chance of a pair of affiliate cats resting together is not dependent on the availability of resting structures. However, closer examination revealed that two affiliative dyads stopped resting together under low complexity conditions while another affiliative dyad that did not originally rest together started to do so after the removal of resting structures. The reason for this is unknown.

4.4.2.3. Notable space-sharing observations

The data collection methods employed in this study allowed detailed recording of how the cats shared the space. Several interesting anecdotal instances were observed. While many instances of cats supplanting or actively taking over a spot from a resting cat were recorded, several cats were observed to not immediately challenge the possession of a favoured spot when they found another cat resting in it. Instead, they left to rest at another spot while continuing to monitor the sleeping cat. Once the sleeping cat left that spot (e.g. to eat), they immediately moved to take over the vacated spot. Other cats were observed to leave a resting spot immediately when they saw another cat (which "favoured" that resting spot) get up and approach it, thereby conceding the possession of that spot without the need for any overt agonistic display. This was done regardless of their relative dominance status, or whether they are affiliates. This suggests that the cats were allowing others an allocated time to use a favoured spot and implies that a complex underlying social interaction may be regulating how the cats shared a limited space.

Another interesting instance suggests that the cats recognized each other first by their coat colour or pattern, and then subsequently by other cues (visual or olfactory). One of the observed rooms contained two black cats which looked alike from a distance. A third cat was affiliative to one of these cats but actively avoided the other. In two separate instances, it approached the black cat which it was not affiliative with (perhaps to rest together with it like how it always did), only to flee away suddenly once it recognized that the black cat was not the one it was affiliative with. Curiously, this phenomenon of cats visually recognizing each other based on coat colour has not been examined in any formal study. Nevertheless, this observation also suggests that the cats had definitive relationships with one another which remained stable over time.

4.5. CONCLUSION

Cats highly prefer elevated and closed spots because they provide “vantage points” for them to survey the surrounding, or hiding places to flee to when subjected to aggressive acts. It is, therefore, of utmost importance for animal shelters to provide sufficient elevated resting places and structures which allow cats to conceal themselves. The providence of ample resting structures is especially pressing when cats are housed at high densities because cats tend to avoid resting close together with non-affiliates. However, under crowded conditions, cats are shown to avoid unnecessary conflict with others in the room by “sticking to their own favoured spots” rather than “rotating the use of favoured spots” like shelves and baskets. This study demonstrated the flexibility of cats to change their space sharing behaviours n response to housing density and enclosure complexity.

CHAPTER 5

QUALITY OF REST IN GROUP-HOUSED DOMESTIC CATS (*FELIS SILVESTRIS CATUS*) IN ANIMAL SHELTERS

ABSTRACT

Measuring resting behavior is an important tool for assessing welfare of captive animals. Generally, longer rest duration, frequent bouts of rest and behavioral signs of relaxation are indicators of quality rest linked with relatively low levels of stress. This study is the first to conduct a detailed tracking of the duration of every bout of resting for 34 cats in an animal shelter, and to investigate the effect of housing density and enclosure complexity on the quality of rest in the cats. Cats housed in high density rooms under low complexity conditions exhibited more short bouts of rest, spent less time performing long undisturbed bouts of resting and were more easily disturbed from their resting spots within 15 minutes of settling down. Cats also showed more restlessness under low complexity conditions, marked by an increase in the number of movements made within the first 15 minutes of settling down. Baskets and shelves encouraged long bouts of rest while cats settling on the ground are more likely to exhibit fragmented rest bouts. These results highlight the importance of providing a complex environment equipped with sufficient resting structures that will promote quality rest and hence improve the welfare of cats housed in animal shelters.

5.1. INTRODUCTION

Resting behavior has been widely studied in a number of captive animals such as bottled-nose dolphins (Sekiguchi and Kohshima, 2003), sperm whales (Miller *et al*., 2008), primates (Anderson, 1998; Reichard, 1998) and captive giraffes (Tobler and Schwierin, 1996) and Asian elephants (Tobler, 1992). An extensive review has also been conducted on the duration of sleep for over 150 species across various taxa (Campbell and Tobler, 1984). These studies have mainly focused on resting posture and the amount of time the animals spent resting. Of greater importance to the understanding of welfare of captive animals are studies which investigated the quality of rest and how it is affected by factors such as enclosure complexity, housing density, social environment and visitor presence. There is a general consensus that good resting quality is indicated by longer resting bouts, higher resting frequencies, and behavioral signs of relaxation. For instance, several studies have shown that rats housed in "enriched cages" performed longer periods of undisturbed sleep behavior compared to rats in the "unenriched" cages (Tagney, 1973; Abou-Ismail *et al*., 2010) and suggested that that is an indicator that enriching cages improves welfare. The welfare of domestic horses was also measured in terms of frequency and duration of lying down (Fader and Sambraus, 2004; Rose-Meierhofer *et al*., 2010) as lying behavior is only observed in relaxed animals.

The reason why resting quality has been linked intimately with animal welfare is because a causative link between resting quality and stress has been frequently reported. For instance, a male Asian elephant was also reported to sleep less and sleep standing up during a stressful relocation to a new herd (Laws *et al*., 2007). Low frequencies of sleep behaviour and low sleep duration also correlates with some indicators of elevated physiological and physical stress in laboratory rats (Abou-Ismail *et al*., 2007). Further advances in electrophysiological monitoring techniques have also revealed that, relative to juvenile macaques reared by their own mothers, those reared by other adults exhibit more frequent periods of arousal from sleep and a relative predominance of non-REM sleep (Kaemingk and Reite, 1987). REM sleep (stands for Rapid Eye Movement) is the stage of the sleep cycle in which dreaming occurs with rapid eye movements underneath closed lids and is thought to be the restorative phase of rest (Crick and Mitchison, 1983). The authors argued that the poorer quality of sleep of the peer-reared juveniles was due to the lower sense of security from resting with others in the absence of the stable and controlling influence of the mother. High visitor density has also been widely accepted as a major source of stress in zoo-housed animals (Morgan and Tromborg, 2007) and it has been shown that low visitor density encouraged behavior suggestive of relaxation in zoo-housed gorillas (Wells, 2005). This shows that sleep measurement is a potentially valuable tool for assessing captive animal welfare. Studying changes in amount, bout length, distribution or type of sleep after exposure to potentially stressful events, could help us understand how animals respond to changes in their environment and provide an additional way of identifying management procedures that have the potential to affect welfare.

In the domestic cat, various studies have reported that an average cat spends 50-65% of its time sleeping (Hart, 1978; Eckstein and Hart, 2000b), making rest the cat’s most frequently performed activity. Resting behavior is affected by various factors such as level of stress, the presence of other individuals and housing density. Stressed cats were found to spend more time alert and attempting to hide (Carlstead *et al*., 1993), and Kry & Casey (2007) found that relaxed cats performed more true resting behavior and less vigilance marked by alert rest. Furthermore, in an animal shelter setting, unrelated adult cats are forced into close proximity with each other where interactions cannot be avoided effectively. Under such housing conditions, some cats have been observed to become totally inactive while others move around the enclosure more and elevated stress levels of other group members (Kessler and Turner, 1999b). A separate study also reports that when cats are housed together for a longer time in the same room with many other cats, they spend less time sleeping than if they were housed at lower densities (Monk, 2008). However, these studies did not provide data on the duration of each bout of rest separated by periods of activity or movement and hence have no records of the amount of undisturbed quality rest the cats had. The present study is the first to investigate how housing density and enclosure complexity affect the resting bout lengths in group-housed cats living under shelter conditions. I predicted that cats would rest in shorter bouts under conditions of higher stress (i.e. higher housing density and lower enclosure complexity) but exhibit longer undisturbed bouts of quality rest under low housing density and high complexity conditions. Excessive movements from spot to spot may indicate higher levels of restlessness, stress, or inability to hold on to a favored spot by cats which exhibit this. Hence, this study also investigated the effect of housing density and enclosure complexity on how much the cats would move around in the presence of others in a limited enclosure space.

5.2. MATERIALS AND METHODS

Refer to Sections 2.2.1., 2.2.2 and 2.2.3 for descriptions of study site, subjects and data collection methodology. Only the data collected from Pets Villa boarding rooms which were selected for removal of furniture to simulate low complexity conditions (rooms 7, 8, 15, 19 and 32) were included for analysis. The duration that each cat spent at each "spot" was tabulated from the raw data collected. Resting bouts were categorized by duration into three categories: short bouts (two to 15 minutes), medium bouts (15 minutes to one hour) and long bouts (more than one hour). "Resting bouts" shorter than two minutes were excluded as these usually occur after an activity (e.g. eating, drinking, interaction with another cat), where a cat is "deciding" where to go next, that is, they do not indicate quality of rest.

Whether or not resting in different types of spots would affect the duration of rest was investigated. For each resting bout length (short, medium and long), the number of times a cat was found settled in the different types of spots (baskets, shelves, ground [side], ground [center]) for that particular bout length was scored. The scores for all the cats in all the high density rooms were summed for each type of spots. The same was done for all the cats in all the low density rooms. Subsequently, the score for each resting bout length was expressed as a percentage of the total score for each type of spot

As continuous sampling was used to record every change in location for all cats at the same time, it was not possible to keep track of the exact time each cat switched from alert rest (with eyes open) to true resting behaviour (with the eyes closed). Instead, two parameters were used to infer the quality of rest: Stay score and Movement score. The Stay score is the average duration (in seconds) a cat was observed to rest at a particular spot. It was calculated separately for each resting bout category, by dividing the total duration of stay by the total number of times it settled down (Table 5.1). For example:

Tale 5.1: A cat spent the following duration at these three spots (for medium bouts)

Spot	Duration	Freq
Shelf (top tier)	34 min12s	2
Basket 1	22 min52s	1
Ground (side)	46 min13s	3
total	1 hr 43 min 17s	6

Stay score = 1 hr 43 min 17s divided by 6 spots
= 1032.83s

This cat spent an average of 1032.83s (or approximately 17 min and 12s) in each of the spots it settled down in. Larger Stay scores imply longer resting duration at a single spot without being disturbed and, hence, is an indication of better quality of rest.

The Movement score is the total number of times a cat changed its location within the enclosure during the entire observation period. It was used as a parameter to infer how restless a cat was. The higher the movement score, the higher the level of restlessness was inferred, since it indicated that a cat was more frequent in changing its location for rest. The converse was also true: low movement scores indicate that a cat tends to rest for longer periods in those fewer spots.

Since the total amount of time a cat spent “settled down” (as opposed to walking, eating, and other activities involving movement) was not the same for all cats, the amount of time a cat spent engaged in each of the three categories of resting bouts was expressed as a percentage of the total time it spent settled down. For instance, a cat was observed to spend 22% of the total time engaged in short resting bouts, 38% in medium bouts and the remaining 40% comprised of long resting bouts lasting for more than an hour. These percentages will be henceforth called “Stay scores” in the report and were analyzed with non-parametric tests. Mann Whitney *U* tests were used to test if there is any significant difference in the Stay and Movement scores between high and low density rooms. Wilcoxon signed rank test was used to test if there is any significant difference in Stay and Movement scores between high and low complexity conditions.

5.3. RESULTS

Tables 5.2a and 5.2b show the number of times cats were observed to rest in the various types of spots (baskets, shelves, sides of room and center of room) and the respective length of resting bout (short, medium and long) for high density and low density rooms respectively. For instance, in high density rooms, cats were engaged in short resting bouts (two to 15 minutes) in baskets for 16 out of 81 observation, medium resting bouts (15 minutes to one hour) for 33 observations and long resting bouts (more than one hour) in 32 observations (Table 5.1a). Hence, of all the observations of cats resting in baskets, 19.8% comprised of short resting bouts, 40.7% of medium resting bouts and 39.5% of long resting bouts.

Generally, cats housed in high density rooms exhibited similar trends to those in low density rooms. Cats settling in baskets and shelves are less likely to move from rest within 15 minutes of settling there than when they were settled down on the ground (sides and center). Conversely, when cats settled down on the ground, they are less likely to remain resting there for more than 15 minutes than if they were resting in baskets and on shelves.

Table 5.2a: Frequency and percentage of resting bout lengths in different spot types (high density rooms)

	Total for high density rooms				Percentage of total score		
Type of spot	Short	Medium	Long	Total	Short	Medium	Long
Baskets	16	33	32	81	19.8%	40.7%	39.5%
Shelves	28	63	37	128	21.9%	49.2%	28.9%
Ground, side	154	94	22	270	57.0%	34.8%	8.1%
Ground, center	145	21	3	169	85.8%	12.4%	1.8%

Table 5.2b: Summary of the frequency and percentage of each type of spot used for each resting bout length (low density rooms)

	Total for low density rooms				Percentage of total score		
Type of spot	Short	Medium	Long	Total	Short	Medium	Long
Baskets	36	63	43	142	25.4%	44.4%	30.3%
Shelves	50	66	53	169	29.6%	39.1%	31.4%
Ground, side	103	37	3	143	72.0%	25.9%	2.1%
Ground, center	32	6	0	38	84.2%	15.8%	0.0%

5.3.1. Effect of density

Mann Whitney *U* test was used to detect any significant difference in Stay scores between high and low density rooms (Table 5.3). Stay scores for short rest bouts were significantly higher in high density rooms than in low density rooms under the low complexity condition (Z = -2.45, P = 0.014; Table 5.3) but not in high complexity condition (Z = -1.74, P = 0.082; Table 5.3). No significant difference in Stay scores between high and low density rooms was detected for medium rest bouts under high complexity (Z = -0.51, P = 0.607; Table 5.3) and low complexity (Z = -0.35, P = 0.726; Table 5.3), and for long rest bouts under high complexity (Z = -1.50, P = 0.136; Table 5.3) and low complexity (Z = -1.55, P = 0.121; Table 5.3).

Table 5.3: Results from Mann Whitney *U* test on the effect of density on Stay scores.

Resting bout length	**High complexity**		**Low complexity**	
	Z statistic	*p* value	*Z* statistic	*p* value
Short	-1.74	0.082	-2.45	0.014
Medium	-0.51	0.607	-0.35	0.726
Long	-1.50	0.136	-1.55	0.121

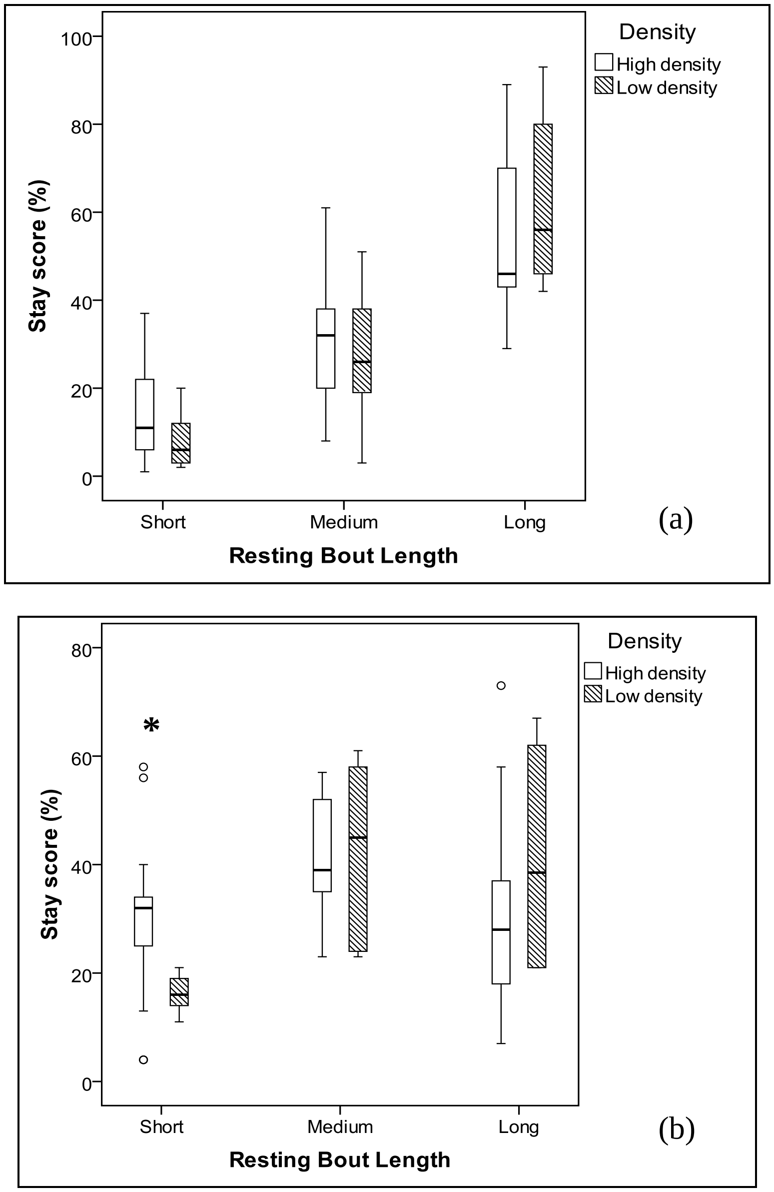
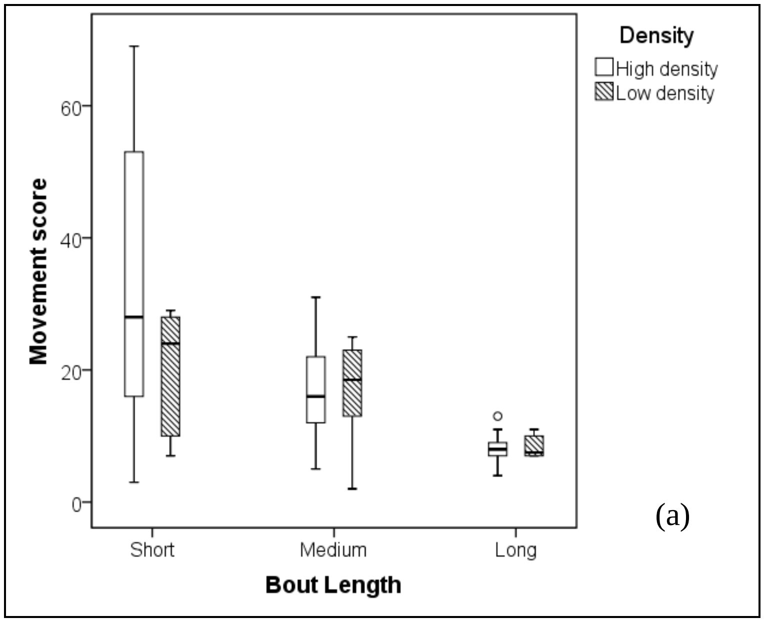


Figure 5.4: Effect of density on Stay scores in short, medium and long bouts of resting under (a) high and (b) low complexity condition. P value: * <0.05 ** <0.01 *** <0.001.

Analysis of Movement scores showed the same trends as Stay scores (Table 5.5). Movement scores for short rest bouts were significantly higher in high density rooms than in low density rooms under the low complexity condition (Z = -2.25, P = 0.025; Table 5.5) but not in high complexity condition (Z = -1.88, P = 0.060; Table 5.5). No significant difference in Movement scores between high and low density rooms was detected for medium rest bouts under high complexity (Z = -0.84, P = 0.404; Table 5.5) and low complexity (Z = -0.41, P = 0.628; Table 5.5), and for long rest bouts under high complexity (Z = -0.82, P = 0.410; Table 5.5) and low complexity (Z = -1.21, P = 0.226; Table 5.5).

Table 5.5: Results from Mann Whitney *U* test on the effect of density on Movement scores.

Resting bout length	**High complexity**		**Low complexity**	
	Z statistic	*p* value	*Z* statistic	*p* value
Short	-1.88	0.060	-2.25	0.025
Medium	-0.84	0.404	-0.41	0.682
Long	-0.82	0.410	-1.21	0.226



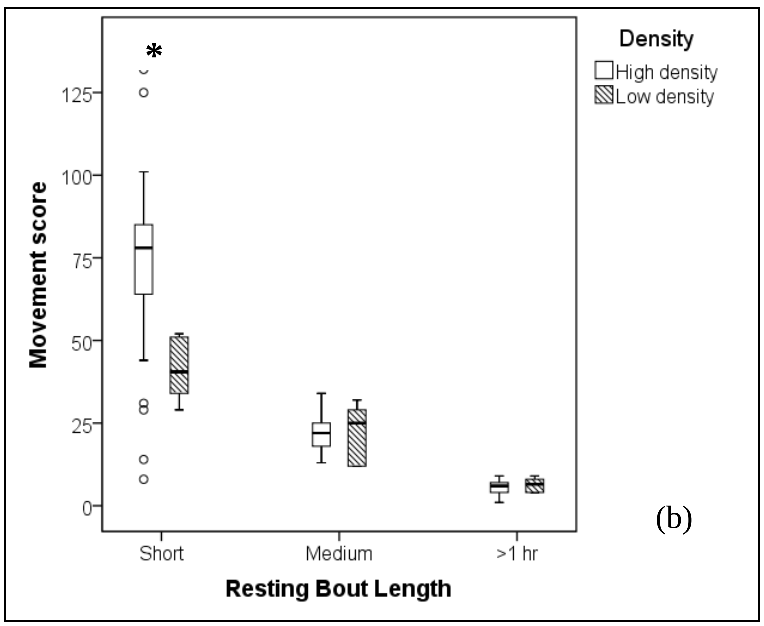


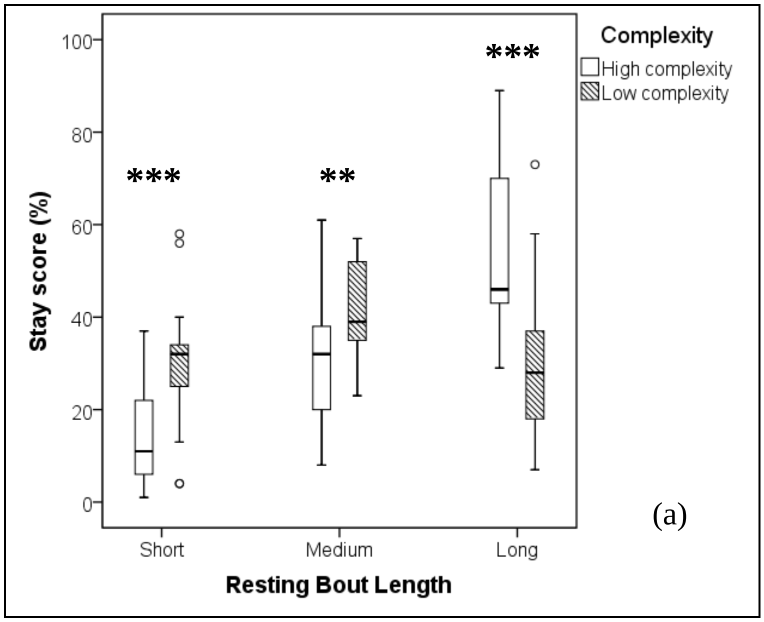
Figure 5.6: Effect of density on Movement scores in short, medium and long bouts of resting under (a) high and (b) low complexity condition. *P* value: * <0.05 ** <0.01 *** <0.001.

5.3.2. Effect of complexity

Wilcoxon signed rank test was used to detect any significant difference in Stay scores between high and low complexity conditions (Table 5.7). In high density rooms, Stay scores under low complexity conditions were significantly higher for short rest bouts *(Z* = -3.842, *P* < 0.001; Table 5.7), medium rest bouts *(Z* = -3.445, *P* = 0.001; Table 5.7) but lower for long rest bouts *(Z* = -3.946, *P* < 0.001; Table 5.7). In low density rooms, Stay scores under low complexity conditions were significantly higher for short rest bouts *(Z* = -2.201, *P* = 0.028; Table 5.7) and lower long rest bouts *(Z* = -2.207, *P* = 0.027; Table 5.7) but not significantly different for medium rest bouts *(Z* = -1.261, *P* = 0.207; Table 5.7).

Table 5.7: Results from Wilcoxon signed rank test on the effect of complexity on Stay scores

Resting bout length	**High density**		**Low density**	
	Z statistic	*p* value	*Z* statistic	*p* value
Short	-3.842	< 0.001	-2.201	0.028
Medium	-3.445	0.001	-1.261	0.207
Long	-3.946	< 0.001	-2.207	0.027



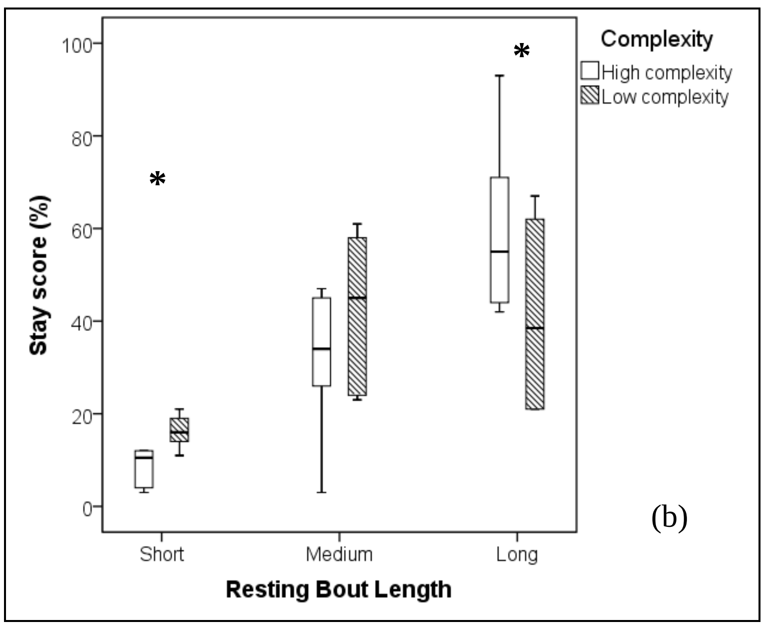
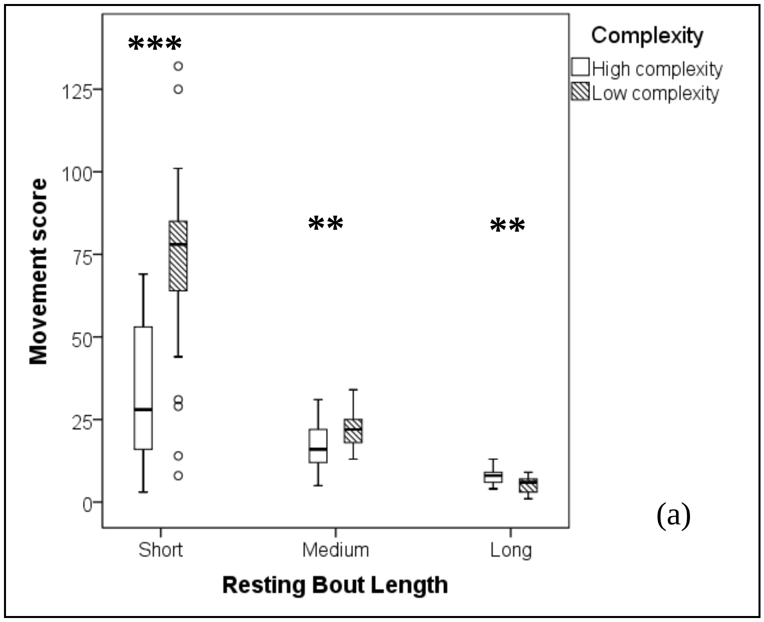


Figure 5.8: Effect of complexity on Stay scores in short, medium and long bouts of resting in (a) high and (b) low density rooms. *P* value: * <0.05 ** <0.01 *** <0.001.

Analysis of Movement scores revealed similar trends (Table 5.9). In high density rooms, Movement scores under low complexity conditions were significantly higher for short rest bouts (Z = -3.77, P < 0.001; Table 5.9) and medium bouts (Z = -3.05, P = 0.002; Table 5.9) but lower for long rest bouts (Z = -3.41, P = 0.001; Table 5.9). In low density rooms, Movement scores under low complexity conditions were significantly higher for short rest bouts (Z = -2.20, P = 0.028; Table 5.9). Movement scores for medium (Z = -1.57, P = 0.116; Table 5.9) and long rest bouts (Z = -1.63, P = 0.102; Table 5.9) were not significantly affected by complexity in low density rooms.

Table 5.9: Results from Mann Whitney *U* test on the effect of complexity on Movement scores

Resting bout length	**High density**		**Low density**	
	Z statistic	*p* value	*Z* statistic	*p* value
Short	-3.77	< 0.001	-2.20	0.028
Medium	-3.05	0.002	-1.57	0.116
Long	-3.41	0.001	-1.63	0.102



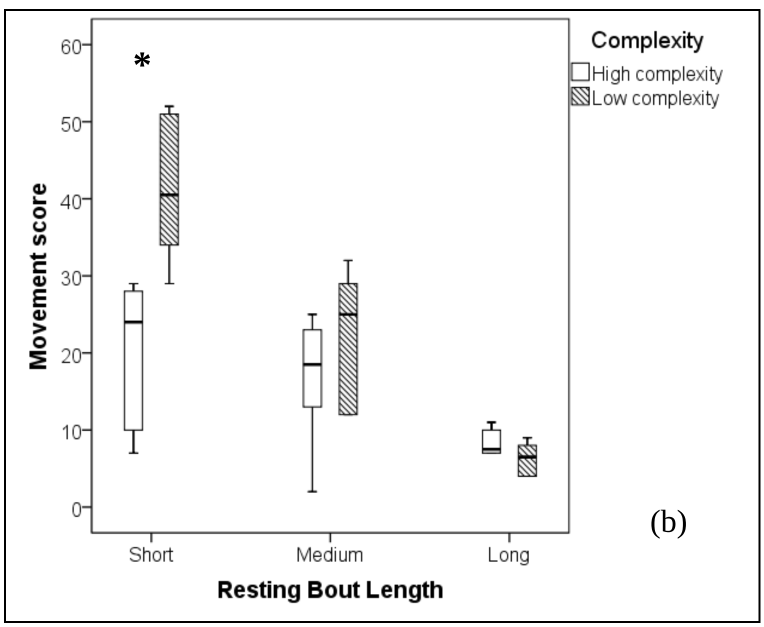


Figure 5.10: Effect of complexity on Movement scores in short, medium and long bouts of resting in (a) high and (b) low density rooms. *P* value: * <0.05 ** <0.01 *** <0.001.

5.4. DISCUSSION

This study conducted a detailed tracking of the duration each cat spent at each spot for all the cats at the same time. Although this disables the distinction between time spent in the truly resting behavior, alert rest and even auto-grooming, it provides important information on the fragmentation of rest and level of disturbances the cats experience in the animal shelters. The "short resting bouts" described in this study refers to a series of events in which a cat is observed to settle down at one spot, remain stationed there for two to 15 minutes before getting up to perform another action or to move to another spot. Although some cats have been observed to switch from alert rest to true resting behavior within this short period of time, the majority remained vigilant and did not close their eyes to sleep until after they have settled down for more than 15 min at that spot (personal observation). An average sleep cycle of a cat is also estimated to last for about 40 minutes if REM sleep (the true, restorative dreaming stage of the sleep cycle) occurred (Ursin, 1970). Hence, if a cat spends a relatively higher percentage of settled down time engaged in such short resting bouts, it is considered to have experienced a higher level of disturbance and is unable to engage in prolonged, undisturbed rest. High quality sleep (REM sleep) was assumed to have occurred for bouts of rest lasting over an hour.

What causes a cat to terminate its "rest" at a spot varies, and it is difficult to pinpoint or to predict the source of each "disturbance". Sometimes, a cat may move from its resting spot in response to the approach of another cat (van den Bos and Buning, 1994), while at other times, the cats terminate their rest in order to eat or drink or to visit the litter box. Most of the time, though, there seems to be no apparent reason why a cat decided to change its resting spot. However, it was observed that resting in different types of spots would affect the length of time a cat would stay there. Generally, cats settled on the ground (sides and center) were more likely to move away from the spot within 15 minutes of settling down than if they were settled in baskets and shelves. This is because ground space in the enclosures is limited and a cat resting on the ground is almost always in full view at eye level to all other cats resting on the ground. This promotes mutual gazing among the cats and since prolonged eye contact tends to escalate into agonistic displays (Crowell-Davis *et al*., 2004), the cats may be avoiding conflicts by simply getting up and moving away quickly. Conversely, most of the long undisturbed bouts of resting were observed to occur when the cats were resting in baskets and shelves and almost no resting bouts that lasted for more than an hour were observed when cats rested on the ground, especially for low density rooms. However, cats housed in low density rooms showed a slightly higher percentage of short rest bouts on the ground (sides) relative to those housed in high density rooms. This implies that cats in low density rooms are more likely to settle down on the ground (sides) than those in high density rooms, but that they are highly likely to get up from rest and move into baskets or shelves within 15 minutes of settling down. The overall results imply that resting on the ground may be more stressful than resting in more visually segregated spots like baskets and shelves. It is therefore recommended that animal shelters should provide visual barriers like deep-sided trays around the sides of an enclosure to create individual "cubicles" in which the cats could rest without being in view of others (Rochlitz, 1999).

5.4.1. Effect of density

Cats housed in high density rooms were found to spend more time engaged in short resting bouts than those housed in low density rooms. They also had higher Movement scores within the same category of resting bouts. However, no difference was found for medium and long resting bouts. This implies two things. Firstly, that within the first 15 minutes a cat has settled down, a cat housed together with many other cats was more likely to stand up and change its resting location relative to a cat housed together with fewer animals (Monk, 2008). Secondly, it also implies that cats housed in high density rooms are more likely to change their resting locations several times (each bout lasting less than 15 minutes) before staying more "permanently" in a spot to sleep. This phenomenon seems to show that cats in higher density rooms are either more "choosy" about where they are resting in relation to the locations of other group members, or are more likely to be disturbed from their rest. It is probably a combination of the two elements. The first conjecture implies that social environment plays a role in the selection of a resting spot in domestic cats. The effect of individual animals on the habitat use and structural preference of other group members has been demonstrated in captive lowland gorillas (Stoinski *et al*., 2001). In the present study, several instances in which a cat moved to settle down in a spot was immediately followed by a cat also joining or leaving the vicinity were recorded (personal observations). The fact that this phenomenon is only observed under low complexity conditions probably reinforced this speculation. This is because under low complexity conditions, baskets and shelves were not provided and the cats could only rest on the ground. This brought the cats into even closer proximity of and direct visual range to each other (especially in high density rooms). Under such circumstances, it is more likely that a cat would settle down in a spot only to move away after monitoring the response of others to its presence at that spot. At the same time, high housing density coupled with low enclosure complexity are highly stressful situations (Kessler and Turner, 1999a; Morgan and Tromborg, 2007), and the increase in short resting bouts and in movement could also be reflective of stress.

Housing density alone did not affect the quality of rest and amount of movements under high complexity conditions, implying that providing an enriched environment is of higher priority to keeping housing density low. This is particularly applicable as animal shelters are often space-limited and have to house animals at densities higher than is recommended (Kessler and Turner, 1999a). Effort should be focused, instead, on providing a complex environment to accommodate all the animals in the room.

5.4.2. Effect of complexity

The removal of baskets and shelves resulted in a significant increase in the amount of time the cats spent in short bouts of rest and decreased the time engaged in long undisturbed bouts of rests lasting over an hour. This occurred regardless of the housing density of the rooms. This suggests that the absence of resting furniture increased stress levels of the cats and caused a reduction in the amount of quality rest they have. Several studies have also shown that rats housed in "enriched cages" performed longer periods of undisturbed sleep behavior compared to rats in the "unenriched" cages (Tagney, 1973; Abou-Ismail *et al*., 2010). Analysis of movement scores for high density rooms also showed a significant increase in the number of movements when baskets and shelves were removed, regardless of the length of resting bout. This points to a phenomenon in which the cats were more restless, and were more likely to terminate their stay at a particular spot to "explore" or change to another location, when resting structures were not. It may merely reflect an adaptive phase of "getting used" to the loss of resting structures instead of truly reflecting the effects of stress induced by a reduction of enclosure complexity. Unfortunately, the animal shelter did not allow the removal of resting structures to remain overnight or to last for more than five observation days and the question of whether the cats have "adapted" to the absence of furniture within the observation period remains unknown. However, movement scores for low complexity, low density conditions showed no significant difference for the "long resting bouts" (Figure 5.10) between high and low complexity conditions. This implies that the cats had engaged in similar bouts of long quality rest despite the removal of furniture and suggests that cats housed in low density rooms experience lower levels of restlessness following a stressful event.

5.5. CONCLUSION

Measuring resting behavior is a valuable tool for assessing welfare of captive animals since changes in resting characteristics are often an indicator of stress. High housing density alone did not affect the quality of rest for confined domestic cats, but when coupled with low enclosure complexity, it elevates stress levels and caused a reduction in rest quality and an elevation of restlessness. Cats were also found to be more easily disturbed from rest if they rested on the ground than if they were in baskets or shelves. Indeed, most of the long undisturbed bouts of rest were taken in baskets or shelves. These evidences point to the importance of enriching the housing environment of domestic cats by providing more baskets and shelves or to line the sides of the enclosure with deep-sided trays. These structures will enable the cats to have higher quality of rest and hence will markedly improve their welfare in animal shelters.

CHAPTER 6

GENERAL DISCUSSION

The main objective of this thesis was to study the lives of domestic cats housed in groups in animal shelters. In the two local animal shelters studied, a unique social situation was set up such that unrelated adult cats of both sexes were housed together in relatively stable groups over long periods of time (at least one year). Their housing situation differed from laboratory cats in that laboratory cats are usually housed singly (Sterman *et al*., 1965; Kuwabara *et al*., 1986) while these shelter cats are housed together and have first encountered each other as adults. Also, as opposed to traditional shelters which put up their cats for adoptions, the cats in this study experience a more stable social situation with minimal addition of new individuals or removal due to adoptions. This is because the cats in each room typically "belong" to one or two "owners" who rent the boarding rooms to house their cats and visit occasionally to interact with their pets. This group-housing situation, again, differs from that of "household cats" in multi-cat families in that cats housed in homes usually have access to at least two rooms and have greater environmental heterogeneity (Bernstein and Strack, 1996; Barry and Crowell-Davis, 1999) than the shelter cats that are more confined in their movements and are provided with minimum structural enrichment. As a result, it could be worthwhile to study the impact of this "novel" housing situation on the social, behavioural and welfare aspects of these shelter cats.

One of the most interesting phenomena observed in the course of this study is the unexpected level of "affiliative tolerance" among unrelated cats. In several studies, feral cats are most often observed alone (71-90% of the time), and when they are observed with others, it was usually a mother-offspring group (van Aarde, 1978; Jones and Coman, 1982). In reports of a large cat colony in Rome, only affiliate cats are observed to rest together while non-affiliates tend to avoid each other by spacing out (Natoli, 1985b). Similarly, in a colony of laboratory cats, they were found to prefer resting alone than with others (Podberscek *et al*., 1991). In the present study, however, two surprising observations were made: (1) unrelated cats established stable affiliate relationships with some cats but not others and (2) non-affiliate cats were observed to tolerate each other's presence and could be seen to rest close (but not touching) each other. This is surprising when we consider the highly territorial nature of the domestic cat, where only colony members are tolerated while aggression is typically exhibited by most or all colony members towards unfamiliar con-specifics (Crowell-Davis *et al*., 2004). Even among household cats, littermates are shown to spend more time in physical contact with one another, groom one another more often, and are more likely to feed close to one another than unrelated cats, regardless of the length of time they have lived together (Bradshaw and Hall, 1999). Veterinary institutes also frequently advice cat owners who plan to have more than one cat to ensure that at least one of them, if not all, is a kitten, and to introduce the cats slowly to each other to prevent aggression among the cats (Overall *et al*., 2005).

One explanation for this unexpected affiliation is that some of the cats in this study have come to "accept" others in the room as "colony members" due to prolonged and enforced close proximity with each other (a driving force not found in household cats where they have more room to space themselves out). Affiliative interactions such as nose-touching and allo-rubbing are frequent exchanges observed between specific cats and are behavioral repertoire thought to function as greeting and scent exchange among colony members (Overall *et al*., 2005; Crowell-Davis, 2007). This implies that the social structure of domestic cats might be more flexible than we have previously thought. Not only are they able to live alone or come together amiably with colony members for feeding and breeding purposes but dispersing shortly after, cats show the ability to integrate unrelated con-specifics into their lives. Even more surprising is the observation that non-affiliate cats are able to rest close with each other, sometimes for long undisturbed periods of time.

This is seen most frequently on shelves, where preference for elevated resting space seems to take priority over preference to rest alone. This is also frequently observed under low complexity conditions where the cats were deprived of resting structures and have to share the ground space. Non-affiliate cats which share the space in this manner do not do this without signs of wariness. When a cat approaches a spot adjacent to another cat it is not affiliative with, if the cat already resting in the spot is not deep in sleep, they will turn to mutually gaze at each other, appearing to "assess the situation". The newcomer will then settle down and continue to remain alert for at least another several minutes while the other cat may do the same, or ignore the newcomer and continue its rest. There is no doubt that the cats were "assessing" the identity of the other cat (i.e. identifying each other with visual cues, see Chapter 4, Section 4.4.2.3). However, exactly what is the "deciding factor" for the newcomer to settle down next to the resting cat and for the resting cat to tolerate the company is unknown. What is clear is that among non-affiliate cats, they seem to be specific in their choice of who to rest close to. For instance, one cat would only rest next to another non-affiliate cat and was never observed resting close to any other cats in the room. This was also observed in several other cats in other rooms, in both animal shelters. Different cats also exhibit different degrees of "affiliative tolerance" in that some cats tolerate the relative closeness of several non-affiliates but some cats are only tolerant of just one specific individual. To my knowledge, this is the first time such social dynamics is described in the domestic cat and there is limited information on what the underlying mechanism might be. I suggest that this variation among cats might be attributed to individuality in the cat. Although this study did not assess the individuality and personality of the cats, these traits might go a long way to explain the social dynamics observed in the study.

Individuality in the cat

Many popular books and articles emphasized the personality and individuality of domestic cats (Chazeau, 1965; Necker, 1970; Rockwell, 1978; Johnson and Galin, 1979; Metcalfe, 1980; Alderton, 1983; Palmer, 1983). Individuality in the cat is seen as a complex emergent perception of "the sum total" of an animal's behavior and that the salient features of a cat's individuality are those which "distinguish it from other's" or give it an "identifiable style", in other words, those which differ between individuals. An observer watching several cats behave in a variety of situations may gain an impression of the general patterning and nature of each animal's behavior in relation to that of others. Adjectives such as "friendly", "curious", "bold", "nervous" may be used to describe the cats. At present, scientifically rigorous methods have been developed to rate, describe and distinguish individuals according to the way they perform specific behavioral acts and also in terms of aspects of their overall individuality. Precise definitions of such adjectives have been formulated by Feaver and company (1986). The study assessed the distinct individual style or personality of 14 female cats living in a laboratory colony by observers' ratings and also by direct behavioural measurements over a period of three months. At the end of this period, both observers rated each cat on 18 dimensions. The correlations between the observers' ratings were significantly positive for 15 of the 18 rated items, but only those seven items where the inter-observer correlations were 0.7 or greater were used for further analysis. When the inter-item correlations were calculated, the seven items fell into three groups: (a) alert (active or curious), (b) sociable (sociable with people, fearful of people, hostile to people, tense) and (c) equable. These three groupings seemed to be independent personality dimensions. Cats that scored similarly on the three dimensions had obvious, shared characteristics. For example, three cats that had positive scores on alert and sociable but negative on equable were active, aggressive, "bossy" cats, three other cats with negative scores on all three dimensions were timid, nervous cats, and a third group that had positive scores on all three dimensions were sociable, confident, "easy going" cats.

Individuality may be influenced by early experience. Konrad and Bagshaw (1970) showed that kittens isolated from birth to seven months and then kept with other individuals were slower to explore or settle down and show relaxed play behavior in a novel environment at 15 months of age than were n ormally-reared controls. Early handling also appears to affect the nervousness" or "boldness" of the developing cats. Wilson and company (1965) found that kittens handled regularly during the first 45 days of life approached unfamiliar objects more rapidly and spent more time in close proximity to them at four to seven months than did non-handled controls. "Friendliness" in the cat has also been shown to be affected by a variety of environmental factors. The timing and amount of early handling that a kitten receives (Karsh, 1984), and the number of handlers a kitten has (Collard, 1967) may influence its later "friendliness" towards humans and con-specifics. Variation in male "aggression" and social dominance in the cat has been shown to be related to the male's abilities to monopolise a group of oestrus females and to father offspring (Liberg, 1981).

It is impossible to determine the degree of socialization and age of exposure to humans of the shelter cats in this study. For most of them, at the time of their rescue, they have already past the socialization-sensitive period, which is suggested to begin at two to seven weeks of age (Beaver, 1980). Nevertheless, individuality is readily apparent in this study. For instance, in Mutts & Mittens, several cats in a room are more "friendly" and would approach the cleaner when he entered the room while others flee onto the wooden beam over two meters above the ground. This individuality might also explain why some cats establish affiliate relationships with specific individuals but not others, and why different cats have varying degrees of "affiliative tolerance" towards non-affiliates. For instance, "sociable, confident and easy going" cats would be more likely to form lasting friendly associations with each other while "active, aggressive and bossy" cats may be more selective of their resting associates. Future research could investigate if cat individuality or personality could predict its "ability" to form affiliative relationships under the conditions described in this study. The results of such a study would suggest if “personality assessment” of cats admitted into the animal shelters should be conducted and used to determine their housing arrangements. If cats could be housed in social groups that facilitate establishment of affiliative relationships, it would go a long way to improve their welfare during the stay. It was observed in this study that some rooms were generally “affiliative” while others were generally “agonistic” (Appendix D). More agonistic interactions were recorded in rooms that were agonistic than in affiliative rooms (Tables 2.3, 2.5). Since aggressive encounters are stressful to both the aggressor as well as the victim (van den Bos, 1998), the observations in this study imply that cats housed in generally affiliative rooms are likely to experience less stress because they are subjected to fewer aggressive acts.

Sex, weight and dominance of cat

Although personality and individuality of the cats were not examined in this study, the effect of sex, weight and dominance on various areas were. It was found that the cat’s dominance was not dependent on its weight and sex. In feral cat colonies, males tend to be dominant over females and heavier males tend to be more dominant than lighter males (Liberg, 1981). The importance of weight in determining dominance in feral cats is probably linked to fighting ability and resource holding potential. One study reported that cat weight significantly influenced range size, with heavier cats having larger ranges than smaller cats (Yamane, 1998). In the wild, the motivation to secure larger territories is greater because larger territories tend to overlap more with home ranges of breeding females and would increase a male’s reproductive success (Natoli *et al*., 2007). In other words, feral males are highly motivated to establish as large a territory as possible and to dominate over other males in order to maximize mating opportunities, and since the ability to do so relies on having greater weight, dominance in feral cats tend to correlate with weight. In the animal shelter condition, however, such motivation seems to be absent. Lighter cats have been observed to display dominance behaviors towards cats heavier than them. It implies that the establishment of dominance in animal shelters depends on other less obvious factors. It is possible that in the first few encounters between a pair of cats when they were first introduced to each other, the winner/loser outcome of those interactions might have established a long-lasting dominant-submissive relationship between them. Which of the pair of cats would emerge the "winner" in those interactions can depend on a few factors. For example, instead of the heavier cat always emerging the "winner", perhaps the resident cat would be more "confident" and thus more aggressive in its interaction with the newcomer regardless of their relative weights. A study of aggression between resident-intruder pigs reported that when a "newcomer" was introduced to a resident pig, aggression was most often initiated by the resident (D'Eath and Pickup, 2002). The level of aggressiveness shown by the cats might also rely on their respective life histories, that is, a cat that used to be highly aggressive to others (before the cat owner rescued it and housed it together with others) would also display more aggressive behavior towards its "new group members" regardless of their relative weights, and hence appear to be more "dominant" despite being the lighter cat. For instance, a study on rats found that aggressive behavior of male intruders towards residents was a reflection of their previous social status (Barclay, 2001). Certainly, these are just speculations as to what might have caused dominance in the group of cats observed in the present study to be independent of their weight as we do not know the details of how the cats reacted with the introduction of each cat into the group. It would be interesting to investigate this as resident-intruder tests have never been conducted on domestic cats, and such a study might shed light on alternative mechanisms that determine dominance in shelter cats.

Not only did sex and weight of the cats not influence their dominance, they also had no effect on the level of affiliation and agonism in the cats observed. However, same-sex pairs were less likely to share the enclosure space in a more affiliative manner (Chapter 4) than different-sex pairs. A similar phenomenon was observed in captive ferrets which exhibited less den sharing within sexes than between sexes (Medina-Vogel *et al.*, 2000). In a group of neutered indoor-only cats, male-female pairs also exhibited more social sniffing than did male-male and female-female pairs (Barry and Crowell-Davis, 1999). This implies that housing cats in mixed-sex groups might be more beneficial to their welfare than housing them in single-sex groups as it facilitates space sharing of a more affiliative nature. This is surprisingly overlooked in most publications which recommend housing requirements for animal shelters (Rochlitz, 1999; Overall *et al*., 2005; Rochlitz, 2005, 2007; Ellis, 2009) and should be given due consideration in the allocation of cats to the shelter boarding rooms.

Effect of housing density and enclosure complexity

The effect of housing density and enclosure complexity has been the focus of many studies concerned with the welfare of captive animals. In chicken broilers, it was found that at higher stocking density, the daily mortality was greater for part of the rearing period, the incidence of leg problems increased, the birds' resting behavior was increasingly disturbed, locomotion decreased and lying and preening patterns were affected, presumably due to increased disruption by other birds (Hall, 2001). Crowding was also reported to inhibit social behaviors and affect affiliation and aggression patterns in chimpanzees (Aureli and DeWaal, 1997; Videan and Fritz, 2007). In domestic cats, it was reported that higher housing density is associated with higher cat stress scores (Kessler and Turner, 1999a). Similar trends were observed in the present study. Higher housing density lowers the chance that a pair of cats will be affiliative with each other and cats housed in high density rooms were also more likely to use avoidance and less likely to employ positive association than those housed in low density rooms (Chapter 4). However, housing density alone has limited impact on other social and behavioral aspects. For instance, density did not have any effect on activity budget (Chapter 3) and was not correlated with levels of agonism among the cats (Chapter 2). A separate study also discussed a similar unimportance of density on welfare of broiler chickens (Dawkins *et al*., 2004). It was a large-scale study (2.7 million birds) with the unprecedented cooperation of ten major European broiler producers. Producer companies stocked birds to five different final densities but otherwise followed company husbandry practices. The results of that study showed that differences among producers in the environment that they provide for chickens have more impact on welfare than has stocking density itself.

In the present study, it was found consistently that enclosure complexity had a marked influence on the social behavior, activity patterns and welfare of the cats, one that appears to be greater than that of housing density. While housing density was found to have no effect on activity budget of the cats, changing the enclosure complexity significantly altered various behaviors such as sleeping, idling and grooming (Chapter 3). Cats also showed more restlessness under low complexity conditions, marked by an increase in the number of movements made within the first 15 minutes of settling (Chapter 5). On the other hand, high complexity conditions increased the quality of rest, demonstrated in terms of cats spending more time performing long undisturbed bouts of rest. These differences were not observed between high and low density rooms, except when coupled with low complexity conditions. This implies that priority should be given to ensuring a complex environment for the cats over the maintaining of low number of individuals per room. This means the providence of ample resting structures is critical in ensuring good welfare of shelter cats as these spaces allow them to space themselves out and avoid agonistic encounters more effectively. This is further highlighted by several pieces of evidence indicating strong preference for resting structures by the cats. Firstly, results revealed that the cats strongly "favoured" elevated and closed spots such as shelves and baskets (Chapter 4). Secondly, whenever sufficient resting structures were provided, cats were found to prefer to avoid resting with each other (unless they are affiliates) or to temporally share the highly preferred structures (Chapter 4). Baskets and shelves also encouraged long bouts of rest while cats settling on the ground are more likely to exhibit fragmented rest bouts (Chapter 5). Providence of resting structures at elevated spots was also highly effective in improving cat welfare because it allows them to perform their natural behavior of climbing and jumping as they would in the wild.

In conclusion, this thesis provided an in depth account of the social behavior and activity pattern of group-housed cats in two animal shelters and systematically investigated the effect of housing density and enclosure complexity on the welfare of the animals. The data analyzed in this study has contributed to a more complete understanding of the housing situation in shelters and has provided new insight into the betterment of cat welfare. Future studies should focus on elucidating the mechanisms by which stable relationships among group-living cats are established and formulating measures that would encourage affiliation among unrelated cats in shelters as this would positively influence their experience of living in confined conditions.

Recommendations for animal shelters

1. Provide a complex enclosure space with vertical climbing structures, especially if space is a limited resource or if cats are kept at high densities.
2. Provide at least twice the number of resting spaces such as baskets and shelves than the number of cats per enclosure as cats tend to establish two or more favoured spots.
3. Visual barriers such as deep-sided trays should be placed around the sides of an enclosure to create individual "cubicles" in which the cats could rest without being in view of others.
4. Monitor and record agonistic and affiliative behaviours whenever they are observed.
5. Ensure that each enclosure contains only cats which are affiliative with each other.
6. Monitor the resting behaviour of the cats for as short as 15 minutes a day.
7. Identify cats which are rarely observed to rest for more than 15 minutes at a time. This is a sign of compromised quality of rest. These cats may benefit from single-housing arrangements.

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Appendix A. 1-0 matrices showing dominant-submissive relationships of each room

Key

1: row individual dominant over column individual
0: column individual dominant over row individual
U: unknown (no interactions)
T: tied/same rank

Mutts & Mittens

Room A

Cat	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1		1	1	1	1	1	U	U	1	T	1	U	1	1	1
2	0		U	U	U	T	U	0	0	T	0	U	T	1	1
3	0	U		T	1	1	U	1	1	0	U	1	U	0	U
4	0	U	T		U	0	U	U	0	T	U	U	1	U	T
5	0	U	0	U		U	U	U	U	T	U	U	0	1	U
6	0	T	0	1	U		U	U	0	0	U	U	U	0	U
7	U	U	U	U	U	U		U	U	0	0	U	U	0	U
8	U	1	0	U	U	U	U		0	0	0	U	U	U	1
9	0	1	0	1	U	1	U	1		0	U	1	0	0	U
10	T	T	1	T	T	1	1	1	1		1	1	1	1	0
11	0	1	U	U	U	U	1	1	U	0		U	1	1	U
12	U	U	0	U	U	U	U	U	0	0	U		0	U	U
13	0	T	U	0	1	U	U	U	1	0	0	1		0	U
14	0	0	1	U	0	1	1	U	1	0	0	U	1		T
15	0	0	U	T	U	U	U	0	U	1	U	U	U	T	

Appendix A. (continued)

Room B

Cat	A	B	C	D	E	F	G	I	J	K	L	M
A		U	U	U	U	**1**	**1**	**0**	U	U	U	U
B	U		U	U	**0**	U	U	U	U	U	U	U
C	U	U		U	U	U	U	U	**0**	U	**0**	U
D	U	U	U		**1**	**0**	U	**0**	U	**0**	**0**	U
E	U	**1**	U	**0**		U	U	U	U	U	**0**	U
F	**0**	U	U	**1**	U		U	**1**	U	U	U	**1**
G	**0**	U	U	U	U	U		**0**	U	U	U	**1**
I	**1**	U	U	**1**	U	**0**	**1**		**0**	**1**	**0**	**1**
J	U	U	**1**	U	U	U	U	**1**		**1**	**0**	U
K	U	U	U	**1**	U	U	U	**0**	**0**		U	**0**
L	U	U	**1**	**1**	**1**	U	U	**1**	**1**	U		U
M	U	U	U	U	U	**0**	**0**	**0**	U	**1**	U	

Room C

Cat	21	22	23	24	25	26	27	28
21		**0**	U	U	**0**	U	**1**	T
22	**1**		**1**	U	T	U	**1**	T
23	U	**0**		U	**1**	U	**1**	**1**
24	U	U	U		**1**	U	**1**	U
25	**1**	T	**0**	**0**		**0**	**1**	U
26	U	U	U	U	**1**		**1**	U
27	**0**	**0**	**0**	**0**	**0**	**0**		**0**
28	T	T	**0**	U	U	U	**1**	

Appendix A. (continued)

Room D

Cat	P	Q	R	S	T	U	V	W	X	Y	Z
P		U	U	T	T	U	U	U	**0**	U	U
Q	U		U	**0**	**0**	U	U	**1**	U	U	U
R	U	U		U	U	U	U	U	**0**	U	U
S	T	**1**	U		U	U	**1**	**1**	U	**1**	U
T	T	**1**	U	U		T	U	U	**0**	U	U
U	U	U	U	U	T		**1**	U	**1**	U	U
V	U	U	U	**0**	U	**0**		**1**	U	U	U
W	U	**0**	U	**0**	U	U	**0**		**0**	**1**	U
X	**1**	U	**1**	U	**1**	**0**	U	**1**		**1**	U
Y	U	U	U	**0**	U	U	U	**0**	**0**		**0**
Z	U	U	U	U	U	U	U	U	U	**1**	

Pets Villa

Room 7

Cat	2	4	6	7	8	9
2		U	U	**1**	U	**0**
4	U		**0**	U	**1**	**0**
6	U	**1**		**1**	U	**0**
7	**0**	U	**0**		U	**0**
8	U	**0**	U	U		**0**
9	**1**	**1**	**1**	**1**	**1**	

Room 8

Cat	10	11	12	13	14	15	16
10		**1**	**0**	**0**	U	U	**1**
11	**0**		**0**	U	U	**1**	**0**
12	**1**	**1**		T	**0**	**1**	**0**
13	**1**	U	T		**0**	**0**	**0**
14	U	U	**1**	**1**		**1**	**0**
15	U	**0**	**0**	**1**	**0**		U
16	**0**	**1**	**1**	**1**	**1**	U	
17	**0**	**1**	**0**	**0**	**0**	U	**0**

Appendix A. (continued)

Room 9

Cat	50	52	53
50		**1**	**1**
52	**0**		**1**
53	**0**	**0**	

Room 15

Cat	40	41	42
40		**1**	U
41	**0**		**1**
42	U	**0**	

Room 19

Cat	43	44	45
43		U	**1**
44	U		U
45	**0**	U	

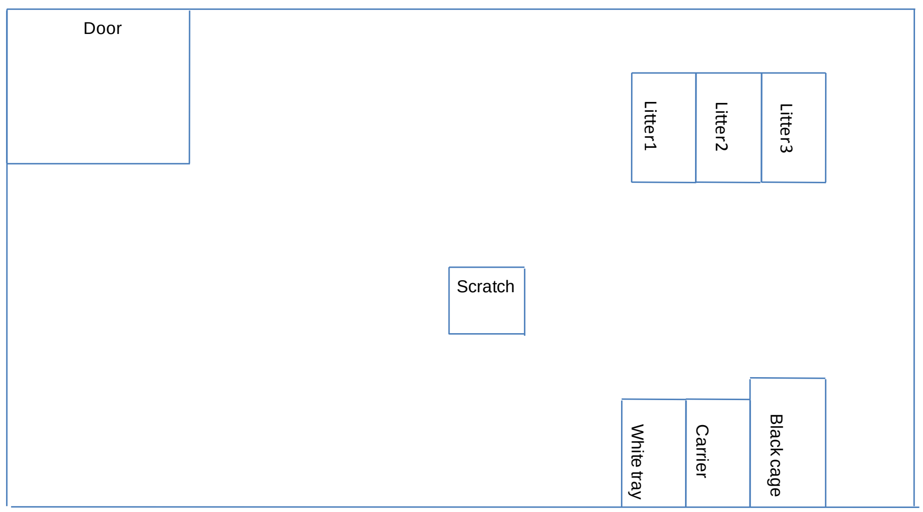
Room 32

Cat	54	55	56	57	58	59	60
54		U	U	**1**	**0**	U	U
55	U		U	U	**1**	**1**	**1**
56	U	U		U	**0**	U	U
57	**0**	U	U		**1**	U	U
58	**1**	**0**	**1**	**0**		**1**	**1**
59	U	**0**	U	U	**0**		U
60	U	**0**	U	U	**0**	U	

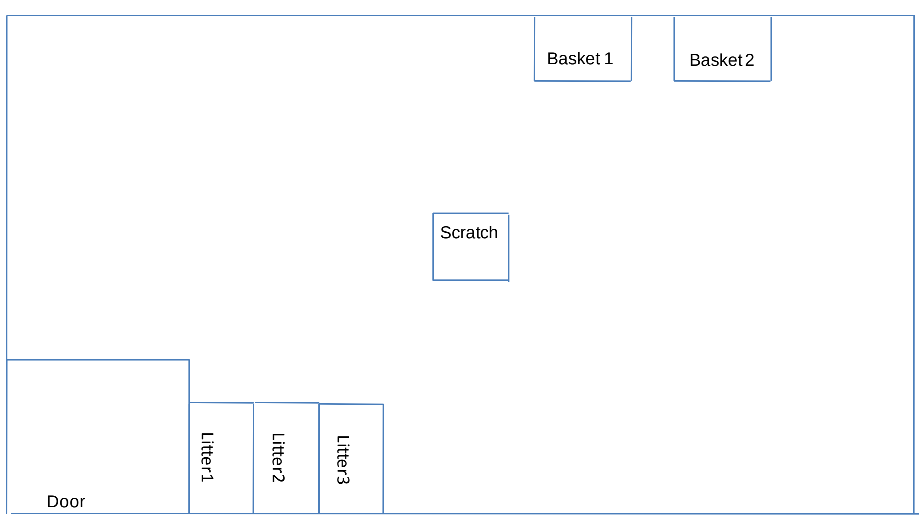
Appendix B. Enclosure sketches

Mutts & Mittens

Room A

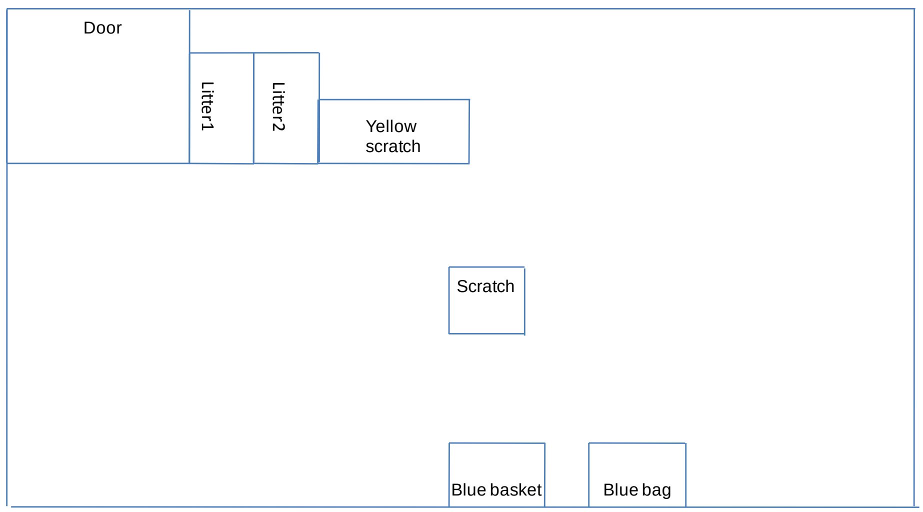


Rooms B, D



Appendix B. (continued)

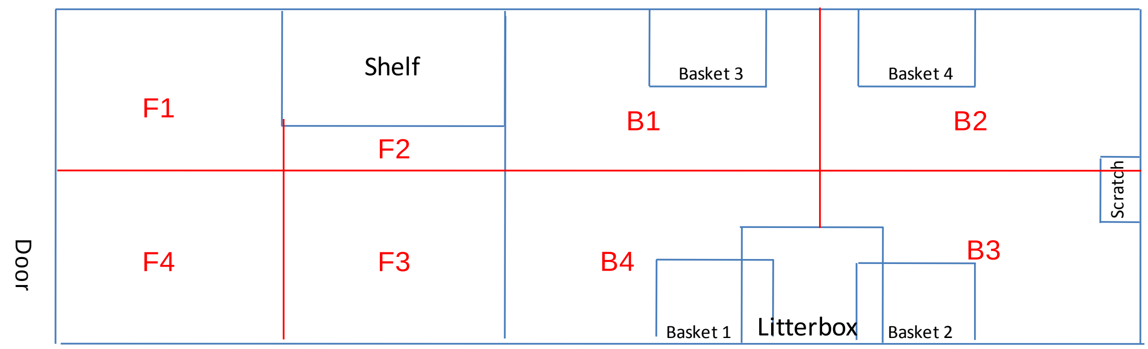
Room C



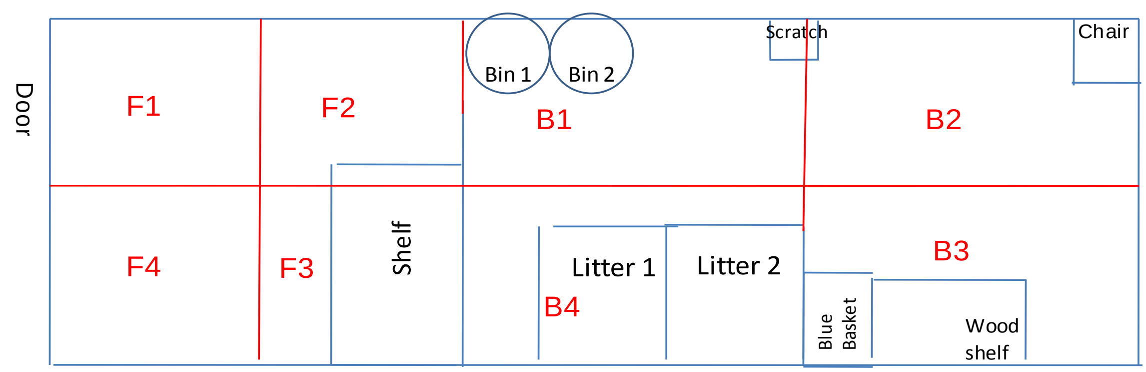
Appendix B. (continued)

Pets Villa

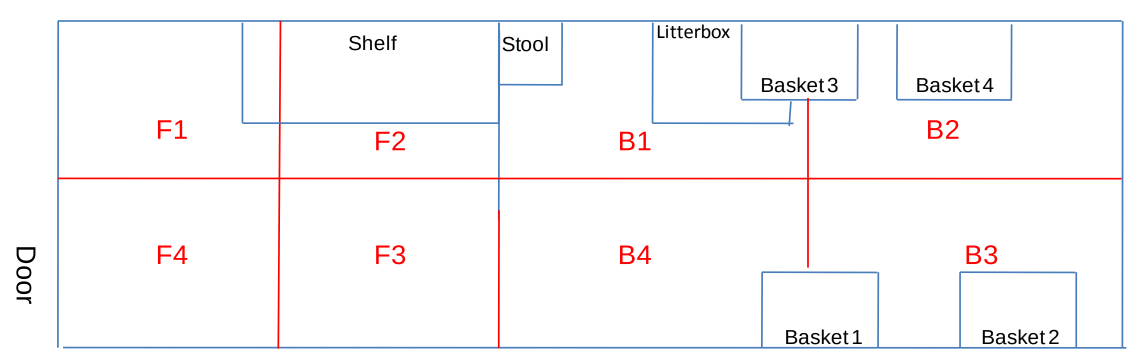
Room 7



Room 8

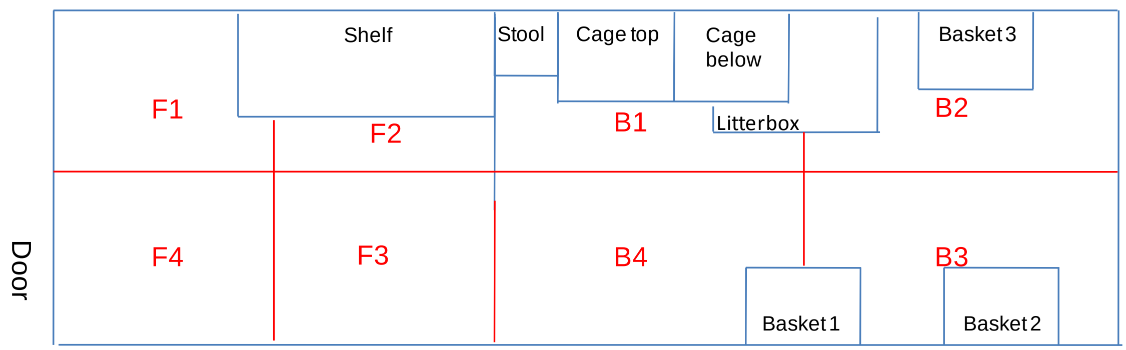


Room 9

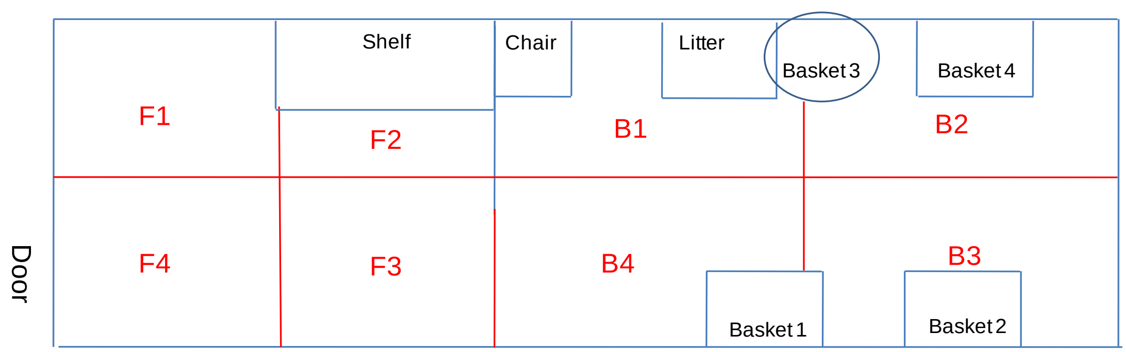


Appendix B. (continued)

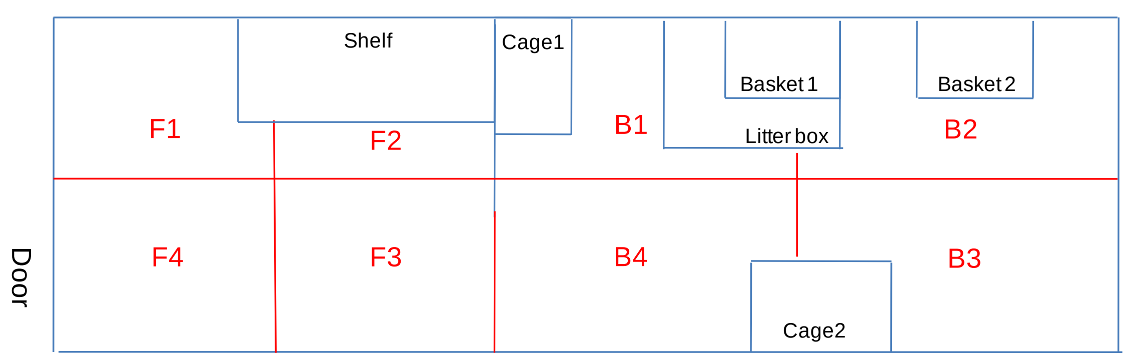
Room 15



Room 19

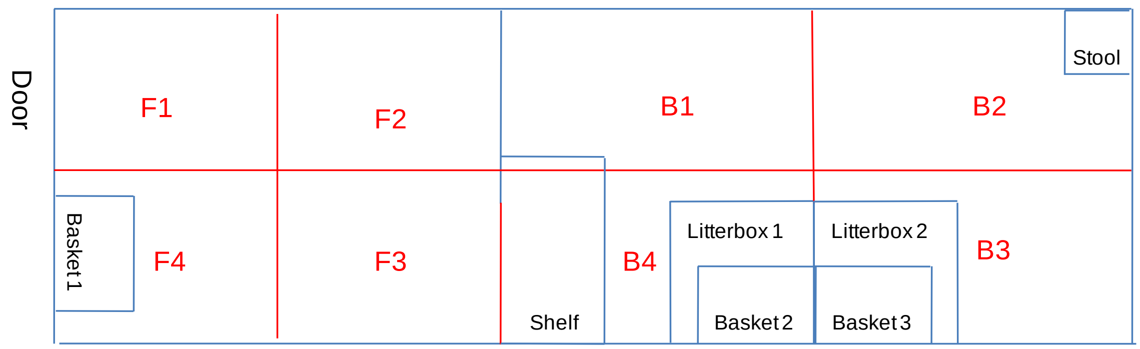


Room 21



Appendix B. (continued)

Room 32



Appendix C. Record of sex, weight and dominance of each cat

Key

Dominance: 0 - dominant; 1 - not dominant; NA - Not Applicable

Mutts & Mittens

Room	Cat	Sex	Weight (kg)	Dominance
	1	M	6.45	0
	2	F	5.8	1
	3	F	1	0
	4	F	4.2	1
	5	F	5.05	1
	6	F	4.9	1
	7	F	3.35	1
A	8	F	3.5	0
	9	F	4.15	0
	10	F	4.5	0
	11	F	3.8	1
	12	F	3.8	1
	13	M	5.6	1
	14	F	5.1	0
	15	M	4.5	1
	A	F	6.65	0
	B	M	4.5	0
	C	F	4.95	1
	D	M	2.4	1
	E	F	4.15	1
B	F	M	5.35	0
	G	F	5	1
	I	M	3.8	0
	J	F	3.3	0
	K	F	2.75	1
	L	F	3.3	1
	M	F	3.2	1
	21	M	4.55	1
	22	M	4.55	0
	23	M	4.2	0
C	24	F	3.9	0
	25	M	4.05	1
	26	F	4	0
	27	F	3.9	1
	28	M	6.05	1

Appendix C. (continued)

Room	Cat	Sex	Weight (kg)	Dominance
D	P	M	3	0
	Q	F	3.3	1
	R	F	3.05	1
	S	M	5.95	0
	T	F	2.75	0
	U	F	2.9	0
	V	M	4.6	1
	W	F	4.5	1
	X	F	4.65	0
	Y	F	3.6	1
	Z	F	4.3	0

Pets Villa

Room	Cat	Sex	Weight (kg)	Dominance
7	2	F	3.1	0
	4	M	4.4	1
	6	M	4.25	0
	7	F	3.85	1
	8	F	6.05	1
	9	M	5.1	0
8	10	F	3.15	0
	11	F	4.8	1
	12	F	3.65	0
	13	F	3.5	1
	14	M	5.5	0
	15	F	4.75	1
	16	F	3.95	0
	17	F	3.75	1
9	50	M	6	NA
	52	F	3.9	NA
	53	M	5.55	NA
15	40	F	4.65	NA
	41	M	4.55	NA
	42	F	3.8	NA

Appendix C. (continued)

Room	Cat	Sex	Weight (kg)	Dominance
19	43	M	4	NA
	44	F	4.35	NA
	45	F	2.75	NA
21	46	M	3.55	NA
	47	F	NA	NA
	48	F	4.05	NA
	49	F	3.9	NA
32	54	M	3.5	1
	55	F	3.45	0
	56	F	3.9	1
	57	F	3.3	0
	58	F	3.95	0
	59	F	3.4	1
	60	F	3.95	1

Appendix D. Affiliation matrices

<u>Key</u>
O - Affiliate pair
X - Non-affiliate pair
? - Ambiguous

Mutts & Mittens

Room A

Cat	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1															
2	O														
3															
4															
5															
6	O	O	X	O											
7		O	O												
8															
9	O		X			?		?							
10	X	X	X			X	?		X						
11		O													
12															
13		X													
14			X			X			X						
15								?							

Room B

Cat	A	B	C	D	E	F	G	I	J	K	L	M
A												
B												
C	O											
D												
E	O	X										
F												
G												
I	O			O	O	O	O					
J								X				
K	O			O			O	O				
L									X			
M						?				O		

Appendix D. (continued)

Room C

Cat	21	22	23	24	25	26	27	28
21								
22	O							
23								
24		O						
25	O	O						
26								
27	X		X	X	O	X		
28		X			O		X	

Room D

Cat	P	Q	R	S	T	U	V	W	X	Y	Z
P											
Q											
R											
S											
T											
U	O										
V						O					
W				X							
X					O	O	O				
Y								X			
Z											

Appendix D. (continued)

Pets Villa

Room 7

Cat	2	4	6	7	8	9
2						
4						
6						
7	O					
8	O					
9	O		O	O		

Room 8

Cat	10	11	12	13	14	15	16	17
10								
11	X							
12		?						
13								
14								
15				X				
16		?	X		?			
17	X	X	X	X				

Room 9

Cat	50	52	53
50			
52	X		
53	X		

Room 19

Cat	43	44	45
43			
44	O		
45	O	O	

Appendix D. (continued)

Room 15

Cat	40	41	42
40			
41			
42		O	

Room 21

	46	47	48	49
46				
47				
48				
49				

Room 32

	54	55	56	57	58	59	60
54							
55							
56	O						
57	O		O				
58	O						
59							
60			O		X		